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The Course of Oil

By K. C. SCLATER

Natural Gas Act

In rendering its opinion on the extent of its jurisdiction as covered by the Natural Gas Act in the case involving the Columbia Fuel Corporation, the Federal Power Commission concluded that Congress had in mind a simpler setup of the natural gas industry than that which actually prevails. Such a setup was based on the assumption that in most instances a single, interstate wholesale transaction intervened between the production of the gas and its resale to ultimate consumers.

"Clearly, Congress thought it was closing the gap in regulation of the natural gas industry by providing Federal Power Commission regulation of companies whose main function was to transport natural gas through interstate pipe lines and sell gas so transported at city gates for resale to ultimate consumers.

"The companies to be subjected to regulation were conceived of as pipe line companies, and it was assumed that production and gathering would enter the field of regulation. The Commission is influenced by the above consideration. The broader conception of its jurisdiction would lead the Commission into attempts to deal with the complicated interrelationship between the natural gas industry and the oil industry.

"The justification for regulation lies in the monopolistic character of the wholesale rates charged for natural gas. The necessity for regulating the price at the well mouth or at the end of gathering lines exists only to the extent that such prices are fixed on a monopolistic basis or by interests with sufficient control in a given field to weaken the force of competition. The record in the present case does not show such control.

"We conclude that it was not the intention of Congress to subject to regulation under the Act all persons whose only sales of natural gas in interstate commerce are made as an incident to and immediately upon completion of such person's production and gathering of said natural gas and who are not otherwise subject to the jurisdiction of this Commission."

The Federal Power Commission in dismissing this case makes it plain that action will be taken to have the Act broadened, should that be found necessary. "Further experience with the administration of the Natural Gas Act may reveal that the initial sales of large quantities of natural gas which eventually flows in interstate commerce are by producing or gathering companies which, through affiliation, field agreement or dominant position in a field, are able to maintain an unreasonable price despite the appearance of competition. Under such circumstances the Commission will decide whether it can assume jurisdiction over arbitrary field prices under the present Act or should report the facts to Congress with recommendations for such broadening of the Act and provision of additional machinery as may appear necessary to clear this gap in effective regulation of the natural gas industry."

It is to be hoped that the Federal Power Commission will not find it necessary to request that the Natural Gas Act be broadened. Such a step, if taken, might eventually involve the oil producer. Every care should be taken by the oil and gas industry to avoid this happening.

●

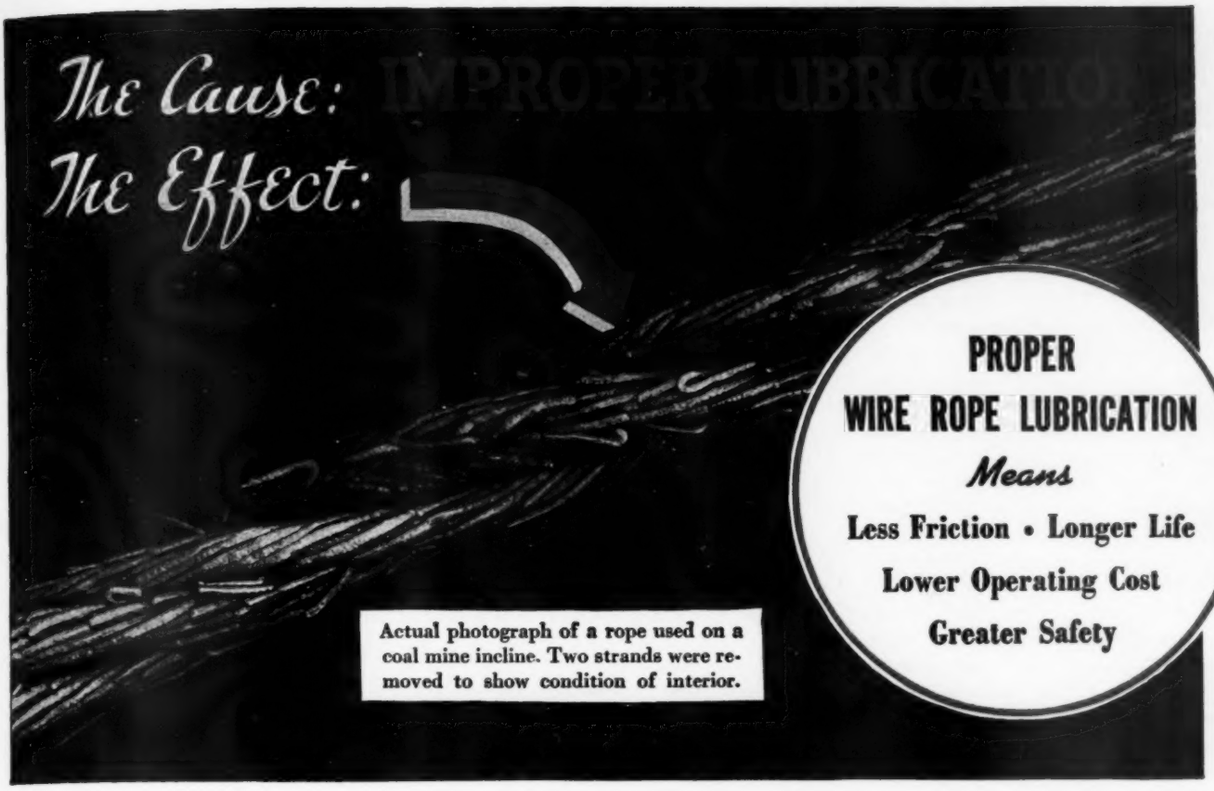
Louisiana's Exploration Requirements

Section three of the Louisiana State Act 77 of 1940, states: "That all persons, firms, associations or corporations to whom such permits are granted shall file with the State Mineral Board authenticated maps showing clearly and in detail the results of the surveys conducted upon said public land; and where the refraction seismograph method is employed, include specifically, and without in anywise limiting the generality hereof, the position of all shot points, detector stations and complete data used for computation of the time velocity curves; and where the reflection seismograph method is employed, include specifically and without in anywise limiting the generality hereof, one complete set of seismograms, a copy of the field map showing the position and location of all shot points and geophones, and a copy of the time chart used in the area of said survey; provided further, that the reports required by this section shall be filed with the State Mineral Board within thirty (30) days after the completion of the Geophysical and Geological surveys."

Section four of the same Act requires: "That any person, firm, association or corporation who makes or causes to be made a geophysical survey of an area which includes any lake, river, or stream beds, or other bottoms, the title to which is in the public, shall within a period of ninety (90) days following the completion thereof, file with the State Mineral Board an authenticated map showing the results of such survey in so far as it applies to such lake, river, or stream beds, or other bottoms, including the immediately contiguous area for a distance of not less than two thousand (2,000) feet on all sides thereof, provided such contiguous area is embraced within said survey."

Pleas for leniency in the provisions of the Act, which applies to State lands, were voiced by operators and geophysical companies. At a meeting in New Orleans last week State officials gave operators an opportunity to be heard on the stringent requirements of the Act. The upshot of the meeting was that a committee of operators was appointed to draft a tentative set of rules. These were presented to members of the State Mineral Board at a meeting in New Orleans this week. It is reported that the state mineral officials disagreed with the tentative rules submitted and intimated that they would write their own rules.

The question at issue is that the law is too stringent and that there should be a more lenient interpretation of the Act. Many of the geophysical companies and operators had commitments to fulfill, which if the new Act is enforced to the letter, will work a hardship, one that could not be foreseen before the law was passed.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« « HIGHLIGHTS IN OILDOM » »

Sinclair Restores Crude Oil Price Cut

Harry F. Sinclair on August 2 restored the crude oil price cut for north and central Texas that had been posted in mid-July. The restoration, which was made retroactive to July 16, was announced at the conclusion of a proration hearing in Austin by the Texas Railroad Commission. The reduction had been to a flat price of 75 cents per bbl. Sinclair stated the price reduction was due to his belief that there was too great a price spread between crude oil and finished products.

Sinclair's announcement came after numerous commendations of the commission and its regulation of the state industry by those at the hearing. Many producers and purchasers went on record in defense of the proration system of conservation.

Commissioner Ernest O. Thompson asserted that more than 50,000 Texas stripper wells would be wastefully abandoned if crude oil prices declined appreciably. He recommended wider well spacing as a remedy.

"Proration has been the dam that has held back the flood of oil that would have wrecked every producer in Texas," Thompson said. "This dam must not be broken. To allow it to be broken would be to betray all the operators who have placed their trust in the laws of Texas and in their faithful administration."

●

Texas Wells Shut-in Nine Days in August

The Texas Railroad Commission, on August 3, took another two days' production off August's crude oil output for the state. An order, signed by all three commissioners, authorized producers to shut-down their wells completely two days this month in addition to the seven shut-in days already imposed. The order was given in view of what the commissioners termed "excessive gasoline and crude oil stocks."

Commissioners Ernest O. Thompson and Jerry Sadler, in the absence of Chairman Lon A. Smith, who agreed to the move, announced the order and stated a 90-day allowable schedule to begin September 1 was under consideration.

Sadler and Thompson stated no further field adjustments were contemplated, except in isolated cases, during the rest of August.

"We have taken this course," Thompson said, "because of the large number of new wells coming in. Gasoline stocks approximate 90,000,000 bbl. over the nation and crude stocks 260,000,000 bbl. We must draw from these stocks to get ready for the low consumption period this fall and winter.

"The best time to reduce these stocks and production is now—during the heavy gasoline consumption period. This will help to stabilize conditions.

"We will appeal, as vigorously as possible, to importers not to increase the amounts of oil brought into this country. Such action would be diametrically opposed to our objectives and obviously unfair to our producers."

●

Sohio Advances Oil Prices in Three States

The Sohio Corporation, effective August 1, advanced crude oil prices in certain fields of Illinois, Indiana, and Kentucky. In the Storms pool, Illinois, the company is paying 93 cents per bbl., an advance of 3 cents per bbl.; in the Heusler pool, Indiana, the price is $1.05 per bbl., an advance of 5 cents per bbl., and in the Birk City and Corydon pools of Kentucky, the quotation is 95 cents per bbl., an advance of 5 cents.

The Sun Oil Company recently has entered the Illinois area as a crude oil purchaser, taking connections in the Centerville, New Harmony, and Phillipstown pools, paying $1.05 per bbl.

●

Oklahoma Lowers Potentials on Class C Wells

W. J. Armstrong, chief conservation officer for Oklahoma, recently announced lower potentials for Class C wells. Potentials for the Fitts group and zones are reduced 2 percent monthly for the next six months; the South Britton, Langston, and North Lucien fields were given a 3 percent reduction. Operators in these fields may take an open-flow test if they desire.

●

40-Acre Spacing For New Oklahoma Field

The Oklahoma Corporation Commission has approved a 40-acre well-spacing program for the Creek County gas field discovered by Walter Brauer et al. The order is applicable to sections 30, 31, and W½ of 32-16n-7e; sections 6 and 7-15n-7e; sections 25 and 26-16n-6e, and sections 12 and E½ of 11-15n-6e. The discovery well is located in SE SW 31-16n-7e. It was completed at a depth of 1140 ft. for a production of 10,200,000 cu. ft. per day.

●

Increased Oil and Gas Taxes in Louisiana

Increased oil and gas taxes resulting from laws passed at the last session of the Louisiana legislature went into effect August 1. Principal among the new taxes was the increased severance tax that raised the levy on low-gravity oil from 4 cents to 6 cents per bbl. and a new gas-gathering tax of ½ cent per 1000 cu. ft. on natural gas. Gas recycled, lawfully burned in flares, used in drilling operations, and in the manufacture of carbon black is exempt from the gathering tax.

●

Court Upholds Kansas Regulatory Law

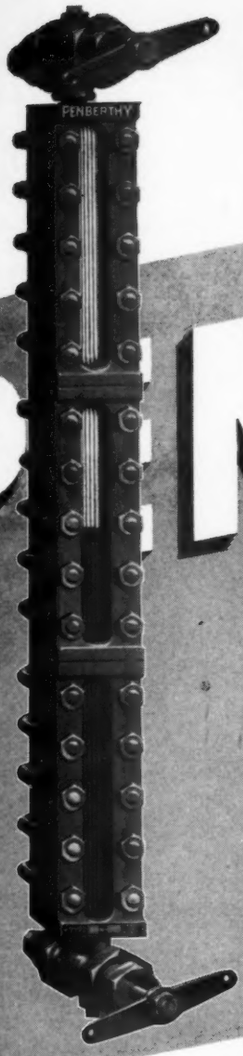
The Tenth Circuit Court of Appeals of Kansas, in handing down a ruling involving the state's new oil and gas conservation law, has held that the state can rightfully charge overproduction against an operator if he runs oil from a common pool in excess of that produced by other operators under an order of the Kansas Corporation Commission.

The decision, which was rendered by Judge Orie L. Phillips, reversed a ruling by Judge Richard J. Hopkins in an action involving Jesse Wall, receiver for the Skiles and Hinerman lease in the Campbell pool, Rice County.

●

Oil Compact Commission to Meet Aug. 23

The Interstate Oil Compact Commission will meet in Oklahoma City, Oklahoma, on August 23. The meeting was called by Governor Leon C. Phillips of Oklahoma. Among those invited to speak at the meeting are Dr. A. G. White of the U. S. Bureau of Mines; Fred VanCovern, director of statistics for the American Petroleum Institute, and H. B. Fell, executive vice-president of the Independent Petroleum Association of America.



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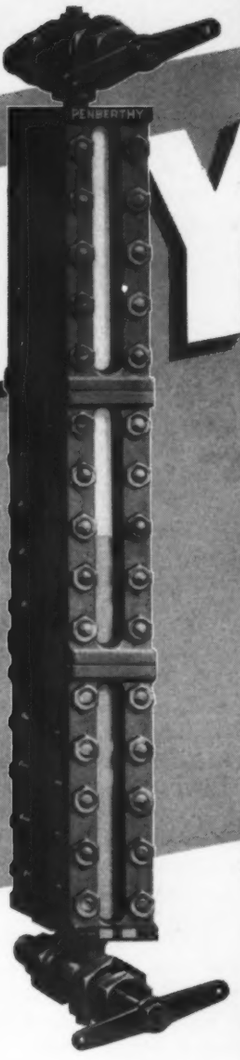

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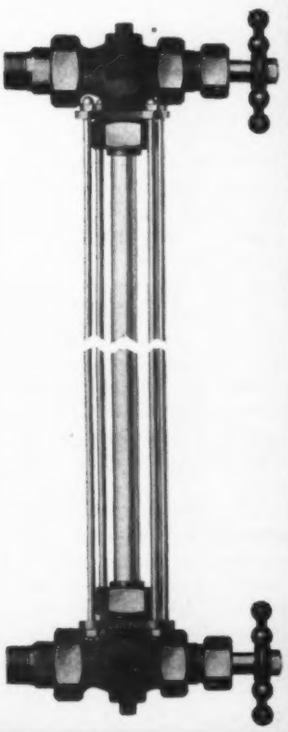

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Percent Refining Capacity Operated

Western Division, 71.4 Percent **Central Division, 74.2 Percent** **Eastern Division, 93.7 Percent**

TOLUENE, the basic ingredient of TNT, will soon be produced commercially direct from petroleum for the first time in the United States, it is announced by Shell Oil Company, Inc., The company will begin construction immediately on a new toluene manufacturing plant at its Houston, Texas, refinery.

This plant, which will produce more than 2,000,000 gal. of TNT-grade toluene annually, represents a major step in the direction of adequate production of TNT explosive for national defense purposes. Hitherto the only source of high-quality toluene has been the coal-tar by-product industry, which, according to recent announcements of the war department, will be unable to supply the quantities required for the new defense program. Since the outbreak of hostilities in Europe, petroleum chemists have been working to develop a process for producing a toluene of sufficiently high purity to be used in the manufacture of TNT.

Shell Development Company, research organization, developed and perfected the toluene process to be employed at Houston. In addition, this organization has perfected a second process, complementary to that used at Houston, and it is understood that by adding this second step, Shell can produce more than 7,000,000 gal. of toluene annually at its Houston refinery alone. Similar plants could also be added at Shell's other large refineries in Illinois, California, and Louisiana.

Shell is deferring construction of the secondary process at Houston as well as toluene plants at its other refineries pending congressional action on the national defense amortization bill. Like a number of other companies, Shell hesitates to invest large amounts of capital in plants for the production of war materials unless there is some assurance the investment may be amortized during the period of high demand that is expected as a result of the rearmament program.

It is understood that Shell is also ready to build a full-scale plant for the production of butadine, a product that Shell Development Company has been producing in semi-commercial quantities for the last 12 months. Butadine is one of the base materials for synthetic rubber. Action in this direction is also dependent on the amortization legislation.

The company's modern refinery at Houston was selected as the site of the initial toluene plant because of its ready accessibility to necessary raw materials and markets. The contract for the construction of the new plant at Houston, involving more than half a million dollars, has been awarded to C. F. Braun and Company, of Alhambra, California, who will start construction at once.

●

Independent Refining Company of Arp, Texas, has signed a license agreement with Universal Oil Products Company and will at once convert its 1500-bbl. per day cracking unit, to increase gasoline yield and improve octane rating of the product.

Absorber and stabilizer equipment and a U. O. P. catalytic polymerization unit will be included in the installation. The latter is expected to produce about 2000 gal. a day of polymer gasoline.

At present the refinery is running about 3500 bbl. of East Texas crude oil daily.

●

Tide Water Associated Oil Company has let a contract to Petroleum Engineering, Inc., of Tulsa, Oklahoma, to construct a combination gasoline stabilizer and vapor-recovery plant for stabilization of 18,000 bbl. of gasoline and 7,500,000 cu. ft. of cracking plant vapors per day, at their Bayonne, New Jersey, refinery. The unit is also designed to recover substantially all the butane and 90 percent of the propane contained in the charge.

●

Pathfinder Petroleum Company of Los Angeles, California, has announced plans to install a catalytic polymerization unit to produce polymer gasoline from the cracked gases produced in its refinery at Los Alamitos.

The "poly" unit will have a rated capacity of 345,000 cu. ft. of gas per day.

H. A. Meek is president of Pathfinder. Bert Devere is vice-president and general manager.

●

Socal Oil and Refining Company of Los Angeles, California, has begun revamping the cracking unit in its refinery at Huntington Beach, California, in order to increase the yield and improve the octane rating of its gasoline.

At present the Socal refinery is running about 3000 bbl. of Huntington Beach crude per day. When revamped the plant will be a 2-coil selective cracking unit having a capacity of 1150 bbl. per day of 16.6° A.P.I. gravity Huntington Beach top[illegible] crude.

C. A. Johnson is president and general manager of Socal, and J. H. Grimes is vice-president and refinery superintendent.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended August 3, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	560	87.1	22,221	24,275
Appalachian	91.0	115	81.0	3,459	872
Ind., Ill., Ky.	90.2	551	82.2	15,304	8,131
Okla., Kans., Mo.	76.9	257	79.6	6,536	3,497
Inland Texas	59.6	104	62.3	1,653	1,779
Texas Gulf	85.3	826	90.4	13,045	12,832
La. Gulf	97.6	117	73.1	2,715	2,886
No. La. and Ark.	51.5	44	84.6	533	754
Rocky Mt.	55.5	52	78.8	1,052	645
California	87.3	501	68.6	15,954	87,826
Reported	85.3	3,127	80.9	82,472	143,497
Estimated Unreported		383		7,020	3,870
*EST'D TOTAL U.S. AUG. 3, 1940		3,510		89,492	147,367
*EST'D TOTAL U.S. JULY 27, 1940		3,555		90,173	144,905
U. S. B. of M. *AUG. 3, 1939		**3,458		77,310	151,107

*Estimated U. S. Bureau of Mines' basis.
**July-August, 1939, daily average.

YOU'VE BEEN ASKING FOR HIGH-VOLTAGE OIL-IMMERSED CONTROL LIKE THIS!

CHECK Its Features against Your Requirements *for:*

EASE OF INSTALLATION

Designed for wall or rack mounting. Needs only four bolts. The cast-iron head, a new feature, keeps the case away from the wall and enables you to make rigid conduit connections from top, bottom, or either side. Power and control terminals are clearly identified and accessible for making connections. Two stainless-steel tank holders provide a simple means for attaching tank.

LOW MAINTENANCE

All operating parts, including overload relays, are immersed in oil. Corrosive fumes cannot get at them. Cast-iron head, mentioned above, resists corrosive moisture that may condense on it. Case is copper-bearing steel painted with aluminum paint. Contactor is of husky construction and contacts are heavy copper.

EASE OF INSPECTION

The operating devices are easily accessible, particularly when the optional tank-lowering mechanism is used. This improved mechanism enables one man to lower and raise tank evenly and accurately with very little effort.

PROTECTION

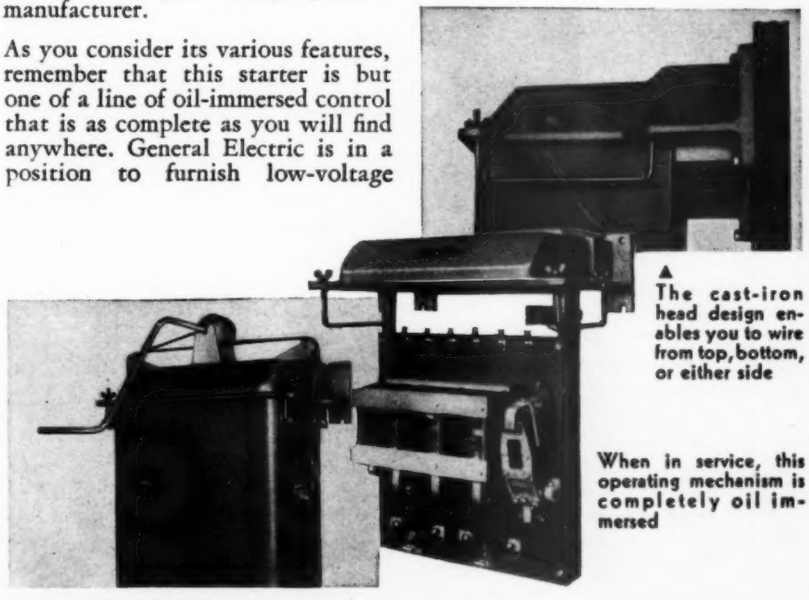
Thermal overload relays, specially designed for operation in oil, protect motor against damage from excessive overloads. They are mounted with contacts at bottom or side to prevent possibility of oil sludge interfering with their action. Undervoltage protection safeguards machines and operators from danger of unexpected restarting after a power interruption. Control and power wiring are widely separated and securely attached to provide maximum protection to operators.

FROM every angle—installation, inspection, maintenance, protection—this G-E oil-immersed starter is *the* motor control for high-voltage service in the corrosive atmospheres of refineries and chemical plants.

Developed to meet specific operating requirements, it is another example of how G-E engineers take the ideas and suggestions of users and incorporate them into improved products such as you expect of a progressive manufacturer.

As you consider its various features, remember that this starter is but one of a line of oil-immersed control that is as complete as you will find anywhere. General Electric is in a position to furnish low-voltage types, as well as high-voltage units with either high or moderate interrupting capacity. This control can also be furnished with contactor and terminals six inches under oil to make it suitable for installation in hazardous gas locations.

Our engineers will be glad to discuss your requirements with you and your contractor. Just get in touch with our nearest representative. General Electric, Schenectady, N. Y.



A The cast-iron head design enables you to wire from top, bottom, or either side

When in service, this operating mechanism is completely oil immersed

The improved tank-lowering mechanism facilitates inspection

GENERAL ELECTRIC

683-3

Activities in the Oil Fields

ONE of the most important recent discoveries in the Gulf Coast area of Louisiana is Union Oil Company's No. 1 Walter White Heirs, drilled on a 10,000-acre block leased by the company in the vicinity of White Lake in Vermilion Parish.

The well is producing 200 to 250 bbl. per day through a ¼-in. choke at a pressure of 3650 lb. The well was drilled to a total depth of 11,098 ft., was then plugged back, and is now producing from a 6-ft. stratum between 10,536 and 10,542 ft.

●

Another pool in Kansas—the twentieth in the state this year—was opened recently in Rooks County by Mitchell Drilling Company's No. 1 Veverka in C S½ SE SE 21-8-19w. After an acid treatment, the well produced at the rate of 1420 bbl. per day from the Arbuckle limestone at a depth of 3425 ft.

●

A new pool in Okfuskee County, Oklahoma, west of the famous Cromwell field, is indicated by the recent discovery in Reese Drilling Company's No. 1 Berryman, NW SW SW 36-11-8e. The well flowed 150 bbl. in 5 hr. while the crew was running tubing. Later, the well produced 515 bbl. of oil in 24 hr. through 2½-in. tubing with 250-lb. pressure on the casing. Production is from the Cromwell sand at 3462-76 ft.

●

National Petroleum Company's No. 1 Spindler, C NW 10-6n-2w, Bond County, Illinois, near the town of Mulberry Grove, is one of the newer Benoist sand pools to be opened in the state. Failing to obtain commercial production from the Misener formation at a depth of 2451 ft., the well was plugged-back to the Benoist at a depth of 1020 ft. The Benoist in this well logged from 1010 to 1040 ft. Seven-in. casing was set, the plug was drilled, and the well given a 20-qt. shot from 1014-19 ft. Operators swabbed 36 bbl. the first hour, then obtained 10 bbl. per hr. as a steady flow.

●

No. 1 Venters, drilled by Harry Moss on the Wright Survey in the Ferndale area of Camp County, Texas, is producing at the rate of 75 bbl. per day through a ¼-in. choke from perforated casing at 8000-42 ft. Pressures on casing and tubing are 90 and 180 lb., respectively.

●

A new pool in Starr County, Texas, is probable as a result of promising tests of No. 1 Yzaquirre, drilled by Complete Oil Well Service Company on a farmout from Sun Oil Company in the SE corner of survey 227. The well was drilled to a depth of 5258 ft. and casing was set at 4970 ft. Two formations, one at 4896-4904 ft. and another at 4610-4630 ft., show good promise of commercial production and another higher sand showed considerable gas when tested.

●

Magnolia Petroleum Company's No. 1-B Mallet, in Hockley County, Texas, a discovery midway between the Duggan and Slaughter fields, is producing at the rate of 100 bbl. in 3 hr. through a ⅜-in. choke from 5044 ft. after a 10,000-gal. acid treatment.

●

An important discovery in Payne County, Oklahoma, recently completed is W. H. Elson et al's No. 1 Murphy, SE NW 20-19-2e. The well flowed 760 bbl. of oil in an 18-hr. test from the Hunton lime through perforations at 4552-84 ft. The well is six miles north of the Ramsey pool.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.12-1.38
Playa Del Rey	.65-1.08
Coalinga	.60- .82
Wilmington	.64-1.14
Montana	.90-1.10
Wyoming	.35-1.30
Colorado	.90- .98
New Mexico	.53- .95
Texas	
North Central	.71-1.03
Panhandle	.67- .96
West Texas	.53- .95
Gulf Coast	.86-1.28
Darst Creek	.96
East Texas	1.10
Talco	.65
Kansas	.60-1.10
Oklahoma	.60-1.10
Arkansas	.73-1.05
Louisiana	
Rodessa	$1.05
Gulf Coast	.79-1.28
North Louisiana	.73-1.05
Illinois	.95-1.05
Kentucky	.90-1.10
Indiana	.95
Ohio	
Lima	.90
Michigan	.74-97½
Pennsylvania	
Bradford	2.00
Southwest	1.65
Eureka	1.59
Buckeye	1.55
Corning	1.12
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (July)	Week Ended Aug. 3, 1940	Week Ended June 29, 1940	Week Ended Aug. 5, 1939
Oklahoma	403,900	[2]410,000	420,450	412,900
Kansas	159,400	[2]183,150	183,100	176,000
Nebraska	.....	[2] 150	150	.....
Panhandle Texas	.....	66,000	61,250	78,050
North Texas	.....	84,750	93,650	94,100
West Central Texas	.....	28,250	30,650	32,600
West Texas	.....	182,600	206,400	319,100
East Central Texas	.....	72,950	72,600	112,200
East Texas	.....	374,850	298,300	522,300
Southwest Texas	.....	174,700	206,300	297,050
Coastal Texas	.....	185,800	211,350	288,100
TOTAL TEXAS	1,339,400	1,169,900	1,180,500	1,743,500
North Louisiana	.....	63,150	68,200	68,000
Coastal Louisiana	.....	216,950	219,550	207,000
TOTAL LA.	278,100	280,100	287,750	275,000
Arkansas	67,400	72,400	72,350	63,400
Mississippi	9,700	[2] 11,750	9,650	.....
Illinois	402,300	406,650	517,050	279,500
Indiana	9,000	[2] 14,750	13,250	97,500
Eastern (not incl. Ill. and Ind.)	94,100	91,700	91,700	
Michigan	61,600	54,750	56,400	67,850
Wyoming	80,600	69,300	79,300	61,700
Montana	18,100	18,750	19,850	16,550
Colorado	4,800	3,550	3,950	4,000
New Mexico	106,100	105,050	105,100	109,100
TOTAL EAST OF CALIFORNIA	3,034,500	2,891,950	3,040,550	3,307,000
California	593,900	601,600	599,000	602,400
TOTAL U. S.	3,628,400	3,493,550	3,639,550	3,909,400

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of July. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi and Indiana figures are for week ended 7 a. m., July 31.

Look to

DOWELL

OIL AND GAS WELL CHEMICAL SERVICE

FOR THE New Mud Acid Treatment *IN SAND FORMATIONS*

Cleans Sands of Drilling Mud

Once again Dowell research rings the bell and announces a most remarkable development—the new Dowell Mud Acid Treatment—the greatest single advance since Dowell introduced its history-making INHIBITED Acidizing. Dowell Mud Acid completely overcomes sand well problems heretofore considered insurmountable. Here is what this new Dowell triumph is and does:

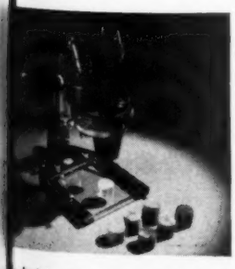
MUD ACID is used in sand wells to remove mud, cement and scale from the face of the pay and from screens and liners. Mud and silt are removed from the formation itself. Thus, with obstructions removed from the formation, screens and liners, the operator is assured of increased production.

MUD ACID actually dissolves bentonitic type muds. The chemical action is not merely disintegration, but truly the taking of materials into solution. Mud Acid is INHIBITED and contains addition agents to lower the surface tension of the solution and to reduce the tendency for emulsion to form between the acid and oil.

DOWELL INCORPORATED

Executive Office: Midland, Michigan
General Office: KENNEDY BLDG., TULSA, OKLAHOMA
Subsidiary of The Dow Chemical Company

FOR years Dowell INHIBITED Acidizing has been increasing the output of wells producing from limestones and sandy limes. Now, as a companion service, Dowell announces the perfecting of the technique of acidizing sand wells. This new Mud Acid Treatment is considered by scores of operators as the greatest advance in the entire history of oil and gas well chemical service. It makes available to the entire industry all of the advantages previously enjoyed only by operators of wells in limestone areas.

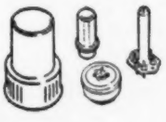


Technicians in the Dowell laboratories conduct hundreds of tests annually on actual sand cores to perfect the new Dowell Mud Acid Service.

More than 100 strictly sand wells on the Texas-Louisiana Gulf Coast have been treated successfully. In every test outstanding results were secured on newly completed wells, workover jobs, old wells and problem wells.

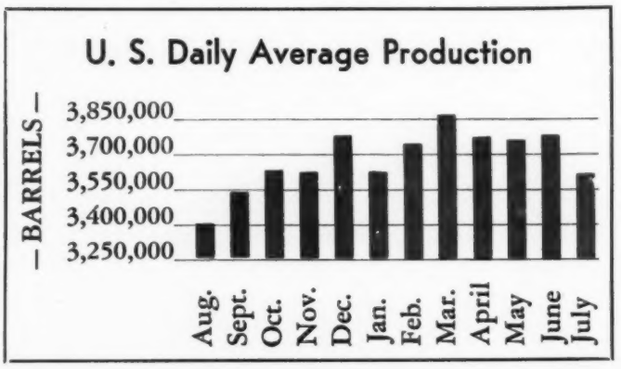
Here again the credit for this important development must go, not to Dowell alone, but to the many operators and producing companies who made it possible to carry on field research work. Working in close conjunction with Dowell's field force were the combined facilities of The Dow Chemical Company, Dowell's parent organization. Thus, more than 500 technicians are engaged in solving these problems. The tremendous advantages this combination of skill and knowledge affords is demonstrated by the many record-making contributions to profitable production which have come from the Dowell laboratories since 1932.

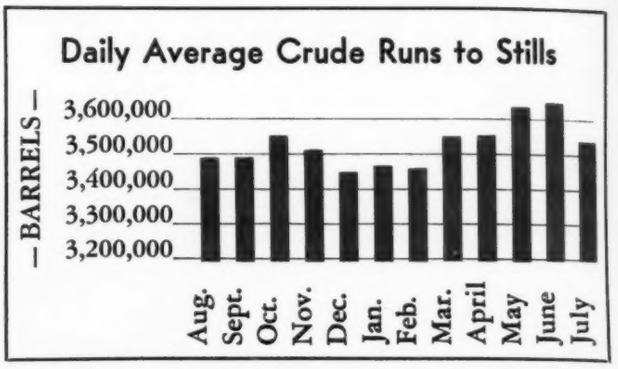
DOW SERVES THE NATION WITH CHEMICAL PRODUCTS—

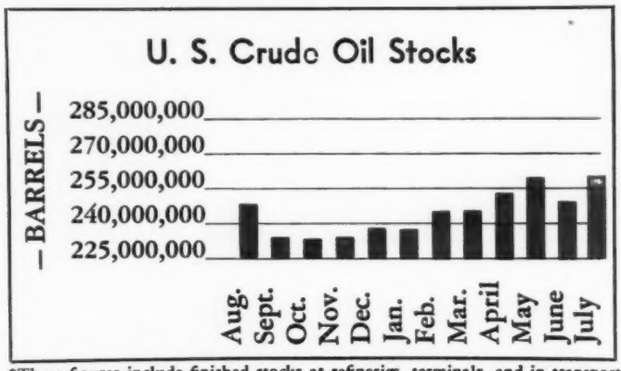


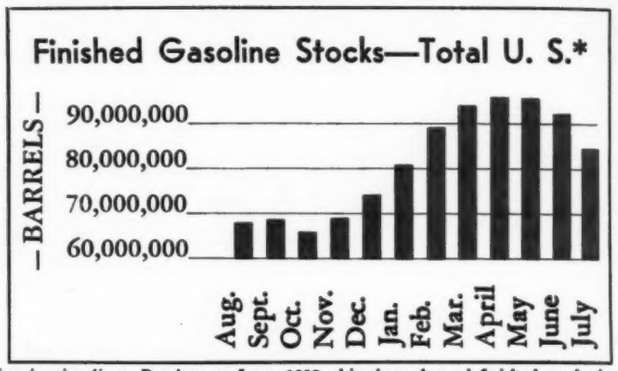
For example: The Dow Chemical Company has also become a leading producer of a wide variety of plastics bringing to many industries new opportunities to benefit from these modern materials.

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

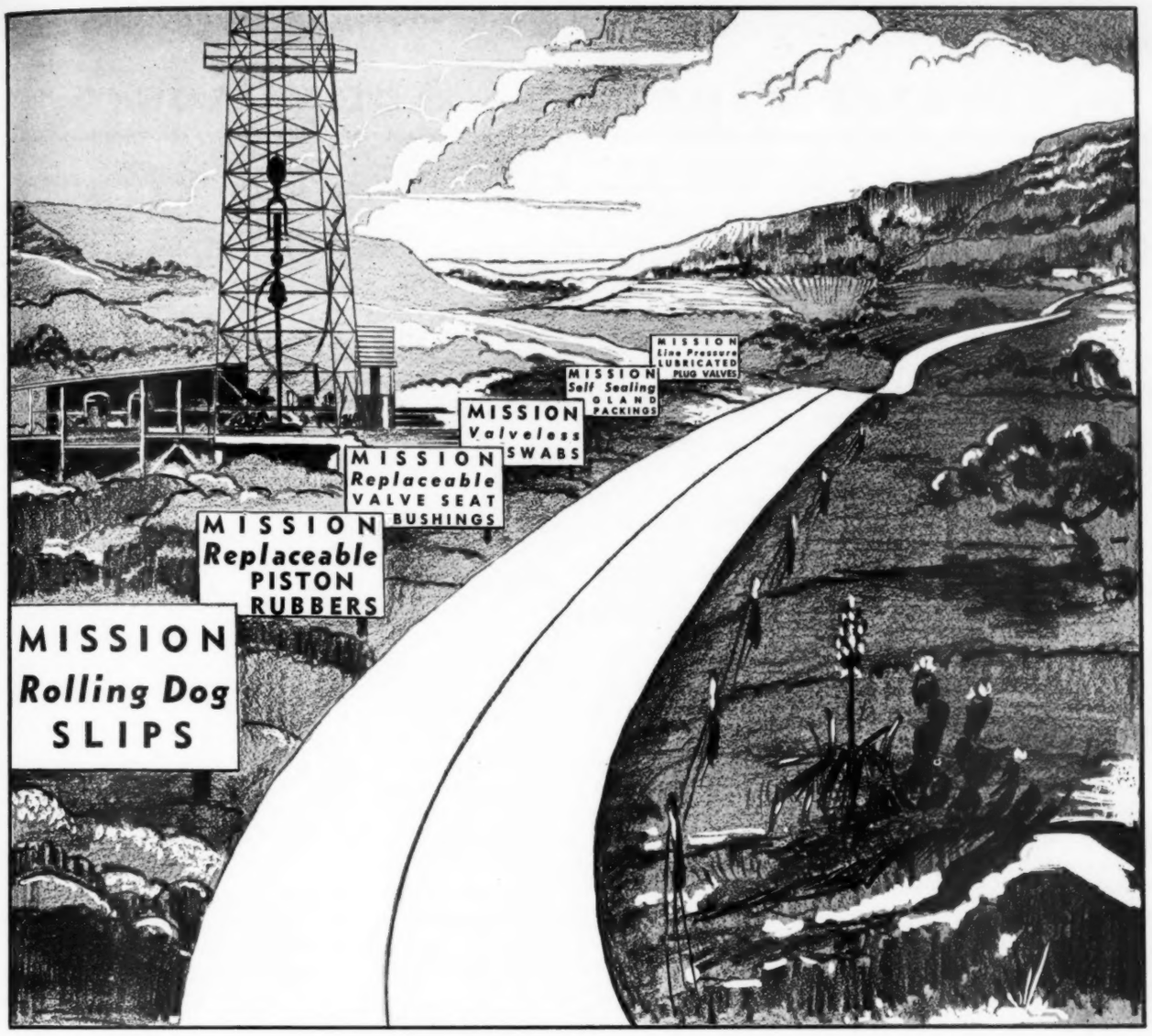
Summarized Operations in Active Fields for July, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	19	17	6	18	3500-3700	2	40	Rotary
Duval County	34	25	8	20	1554-2900	2	22	Rotary
Ector County	45	45	21	51	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	78	76	22	74	1700-3900	2	40	Rotary
Refugio County	6	6	2	3	4900-5900	2	38	Rotary
Nueces County	20	15	2	5	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	28	26	16	50	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Fitts Pool	8	6	1	4	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	33	29	8	19	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	18	15	7	22	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	20	17	4	20	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	340	334	345	151	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	28	26	18	55	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	4	4	3	8	8300-8730	3 or 4	40	Rotary
Wilmington	18	17	10	30	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for July, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	July	June	July	June	July	June	July	June	July	June	
Arkansas	12	14	7	11	17	12	6	5	33	30	21,266,994
California	112	99	100	90	85	74	92	114	175	191	224,336,682
Colorado	1	....	0	....	....	....	3	2	27	29	1,402,599
Illinois	340	391	251	338	506	411	290	338	141	145	92,915,620
Indiana	40	50	24	25	....	....	8	9	60	64	1,426,000
Kansas	193	218	157	172	185	130	40	40	235	238	59,952,340
Kentucky	33	48	12	16	....	....	6	7	82	88	5,611,500
Louisiana	146	182	106	142	113	130	32	35	176	181	94,110,736
Michigan	112	106	46	62	80	92	35	44	155	161	23,185,203
Mississippi	15	23	8	7	....	....	5	7	33	32	102,918
Montana	19	25	17	19	....	....	10	6	40	43	5,901,058
New Mexico	54	52	42	40	41	24	20	24	124	129	37,453,117
New York	101*	95*	101*	95*	....	....	10	11	66	67	5,105,000
Ohio	54	74	41	50	....	....	54	58	187	199	3,157,500
Oklahoma	166	206	88	138	134	105	40	45	265	290	156,421,939
Pennsylvania	184*	188*	180*	181*	....	....	....	....	....	....	17,342,500
Tennessee	....	....	....	....	....	....	....	....	....	....	....
Texas	856	953	678	745	859	733	404	402	1301	1295	485,847,999
West Virginia	46	50	36	42	120	68	21	14	135	120	3,556,500
Wyoming	16	8	10	7	....	....	9	11	67	62	21,408,478
Total	2500	2782	1904	2180	2140	1786	1085	1173	3302	3364	1,260,504,t83

*Includes water-intake and pressure wells.



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Mission Slips: The unique "Rolling Dog" principle prevents slips from sticking in the bowl—eliminating delay and speeding up round trips.

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Mission "Self Sealing" Gland Packings — Valveless Swabs — Line pressure lubricated Plug Valves, all operate on revolutionary principles and all help to make the drilling and producing of oil faster—safer—more economical.

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Major Pipe Line Activities

THE Natural Gas Pipeline Company of America has announced that contracts are being let for major extensions to its pipe-line system. Construction will be carried forward as two projects: (1) extension of facilities to northern Illinois and Wisconsin markets not now served with natural gas and (2) new pipe-line facilities extending into the Texas Panhandle and Hugoton gas fields.

The new construction, bringing gas from Kansas, Oklahoma, and Texas, will double the existing pipe-line facilities and serve large markets in Illinois, Wisconsin, and other eastern states. Many new and important features of pipe-line construction will be embodied in the new line.

These additions were contemplated when the 24-in. main line from the Texas Panhandle to Chicago was built in 1929-30 but were delayed because of business conditions. A substantial part of the right-of-way for the Wisconsin line was acquired in 1932, shortly after the pipe line began operation.

There will be no immediate public financing of the extensive construction program now getting under way. This will be met by the companies holding ownership of the pipe line company.

Although the company is under the jurisdiction of the Federal Power Commission, the provisions of the Natural Gas Act do not require the company to obtain a permit, as the new markets are not served with natural gas at the present time. The opinion rendered by the Federal Power Commission in the Montana-Dakota Utilities Company case on June 18, 1940, supports this position.

The Natural Gas Pipeline Company of America is jointly owned by major companies in the industry. Cities Service Company owns 26.6 percent; The Peoples Gas Light and Coke Company, 21.3 percent; The Texas Corporation, 17.5 percent; Standard Oil Company (N. J.), 13.3 percent; Southwestern Development Company, 13.3 percent; Public Service Company of Northern Illinois, 4.3 percent; Columbian Carbon Company, 2.5 percent; and Commonwealth Edison Company, 1 percent. W. A. Jones, president of Cities Service Company, is president of the pipe line company. Floyd C. Brown is vice-president and general manager. Headquarters are in Chicago, Illinois.

Cities and towns now receiving gas from the pipe line company include Chicago and the metropolitan district; Moline and Rock Island, Illinois; and Davenport, Cedar Rapids, Iowa City, and Ottumwa, Iowa.

●

Construction of Southeastern Pipe Line Company's 450-mile gasoline pipe line from Port St. Joe, Florida, to Atlanta, Georgia, is still being impeded seriously by inability to gain permission from the various state and county authorities to cross highways with the line.

Recent reports indicate that most of the line has been laid but only a few of the sections have been tied-in at highway crossings.

In a recent decision handed down by the Supreme Court of the State of Georgia, it was held that pipe lines do not have, under existing Georgia statutes, the power of eminent domain.

○

Applications of three Pennsylvania operating companies in the Columbia Gas and Electric system to construct a $1,684,769 pipe line to carry 2,500,000,000 cu. ft. of natural gas annually from West Virginia to consumers in New York State has been approved by the Public Utility Commission. The 15-year agreement is for the Pennsylvania companies to accept natural gas from the United Fuel Gas Company of West Virginia for remetering and transportation across Pennsylvania until it reaches the Home Gas Company of New York. All are Columbia Gas and Electric affiliates.

Williams Brothers Construction Company, Tulsa, Oklahoma, has the contract for building the 119 miles of pipe line required as a result of the sales agreement. The contractor has established headquarters at Brookville, Pennsylvania, from which operations will be supervised.

Three months is the estimated time required to complete the line. M. R. Allen is in charge of the work for Williams Brothers. W. D. Budette will represent Columbia Gas and Electric.

●

New Mexico Gas Company's trunk pipe line to Albuquerque from the San Juan field is being supplemented by 9 miles of new line between Bloomfield on the San Juan River to the Animas River northeast of Farmington. The new line is expected to cost $80,000, including reconditioning of the old line, and will give the company loop service that will double capacity of the system.

●

Fifty miles of 12-in. gas pipe line is being constructed by Cities Service Gas Company from the Cunningham gas field to Wichita, Kansas. The work is being done by the company's own construction forces and is expected to be completed in the latter part of September. Constructed of 27.2-lb. pipe, the line is solid-welded in 40-ft. joints. The line will be operated at 700-lb. working pressure and will be tested upon completion at 800-lb. pressure.

●

Construction has been started by the O. C. Whitaker Company on 171 miles of oil pipe line to be built for Socony-Vacuum Oil Company, Inc., between Buffalo and Syracuse, New York. The line will be of 6-in. pipe except for a 7-mi. section of double 4-in. laid in the same ditch. The line is to be stove-piped and completely coated.

Six distributing stations will be built along the line to unload the finished products that will be transported. Main line gates are to be placed at intervals of 3 to 4 miles.

THE Petroleum Engineer

AUGUST, 1940

A PETROLEUM ENGINEER FEATURE

Vapor-Liquid Phase Equilibria in Hydrocarbon Systems

PART VIII

Calculation of the approximate minimum reflux required

By

GEORGE GRANGER BROWN

Professor of Chemical Engineering, University of Michigan

and

DYSART E. HOLCOMB

IN the last installment the minimum number of plates required to accomplish the separation given in Table 9 was computed. In this installment it will be shown how to compute the minimum reflux ratio, $\frac{L}{V}$, corresponding to the minimum cooling at the top of the column, and minimum heat necessary at the bottom to accomplish the same separation. Under conditions of minimum reflux the column will have an infinite number of plates and it is obviously impossible to compute the column by plate-to-plate calculations as was done in the last installment when computing the minimum number of plates.

In the operation of a column of infinite plates, the change in composition from plate-to-plate at the top of the column is very appreciable, as indicated in Fig. 19. The more volatile components, such as ethane and propane in the fractionation represented by Table 9, are reduced relatively rapidly in concentration until they reach a constant value at a position near the top of the column. The change in composition of the cut components, in this case *iso-* and normal butane, is also very appreciable at the top of the column, due in part to the significant temperature changes brought about by the fractionation of the more volatile components. At some point well down from the top of the column, the composition does not change from plate to plate when operating with an infinite number of plates or at minimum reflux ratio. There is, therefore, a wide zone in such a column where the composition of the liquid remains constant.

In the case of a binary mixture this zone of constant composition includes the feed plate, and the composition is the same in this zone as in the liquid part of the feed. This condition would also exist in the case of a complex mixture provided all components in the feed were also present in the overhead distillate, and the separation desired was between the least volatile component in the feed and the next more volatile component.

Usually in complex mixtures the separation is between two components of intermediate volatility, and there are components introduced into the column by the feed that are not pres-

Photographs and biograpical sketches of the writers can be found on page 31 of the July issue of *The Petroleum Engineer*, in connection with Part VII.

ent in detectable amounts in the overhead distillate. These less volatile components are rapidly rectified from the vapors as they pass upward from the feed plate toward the top of the column, as indicated in Fig. 19. Due to the rectification of these less volatile components, the temperature is not constant over those plates directly above the feed plate, and fractionation takes place due to this temperature gradient caused by the rectification of the less volatile components.

If there were no such rectification between the feed plate and the zone of constant composition in the rectifying section, the ratio between the mole fractions of the two cut components would be the same on the feed plate, and therefore in the liquid part of the feed, as in the zone of constant composition above the feed plate. As has been stated, this condition is met when the separation in the upper part of the column is between the two least volatile components in the feed. To determine the minimum reflux under such conditions it is simply necessary to compute the minimum reflux required to reduce the ratio between the more volatile and less volatile cut components to that ratio existing in the liquid part of the feed, but when there is additional fractionation between the zone of constant composition and the feed plate, the minimum reflux is somewhat less than that computed in this manner as it is not then necessary to reduce the ratio between the two cut components to a value as small as that ratio in the liquid part of the feed. This difference is brought about by the fractionation taking place between the zone of constant composition and the feed plate due to the presence of those less volatile components not included in the distillate.

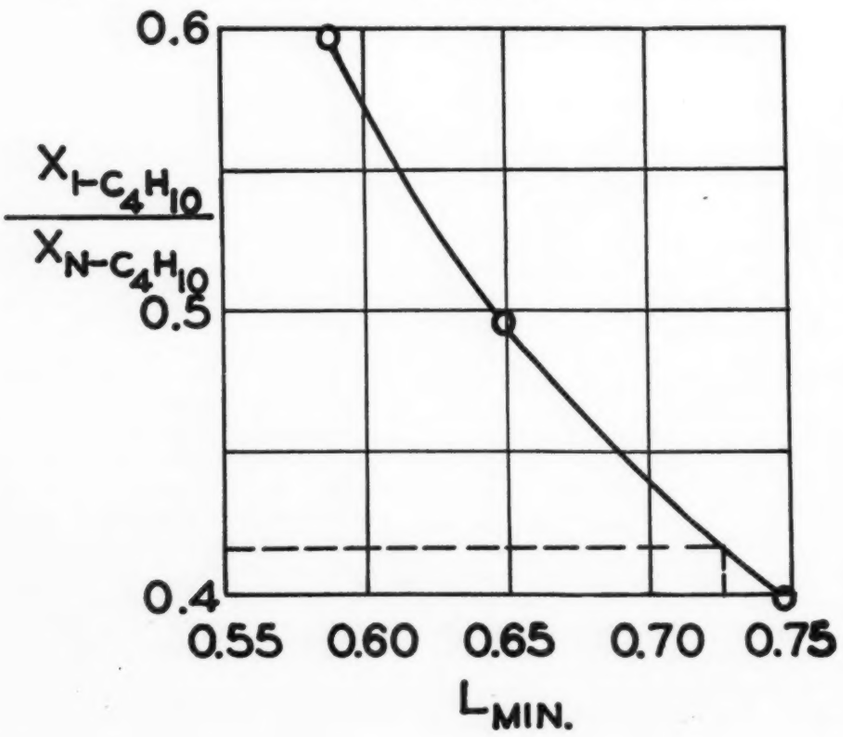
Usually the separation that takes place between the feed and the distillate is either more or less difficult than the separation taking place between the feed and the bottoms. It has been found that the fractionation due to the presence of the less volatile components in the rectifying section of the column is of relatively little significance if the separation required between the feed and the distillate is more difficult than that required between the feed and the bottoms; and similarly the fractionation caused by the presence of the more volatile components between the feed plate and the zone of constant composition in the stripping section of the column is of little significance if the more difficult separation takes place between the feed and the bottom products.

An approximate value for the minimum reflux, which is somewhat higher than the actual minimum reflux, may be readily estimated by computing the minimum reflux required to reduce the ratio between the more volatile cut component and the less volatile cut component to that existing in the liquid part of the feed when this computation is made for that part of the column in which the more difficult separation is occurring or in which is contained a greater number of plates.

From the calculations for the minimum number of plates in the previous installment, it was found that more plates were required above the feed plate in the rectifying section of the column than below the feed plate in the stripping section of the column to accomplish the separation of Table 9 (approximately 8 plates above the feed plate and about 5.7 plates below). This indicates that the separation in the rectifying part of the column is a more difficult separation than that required in the stripping section. The same conclusion could be reached by comparing the ratio between the mole fraction of *iso*butane to the mole fraction of normal butane in the overhead distillate, in the liquid feed, and in the bottoms.

It is, therefore, possible to estimate the minimum reflux by making computations in the rectifying section of the column so that the ratio between *iso*- and normal butane in the zone of constant composition is the same as that in the liquid part of the feed. For this reason the approximate minimum reflux will be computed in this case beginning with the top part of the column.

Fig. 17. Ratio of *iso*butane/*n*butane plotted against minimum reflux, L



The Zone of Constant Composition

In a column wherein an infinite number of plates is required to accomplish a finite change in composition there will be a zone below the top of the column and above the feed plate wherein the composition remains constant over a large number of plates. Under these conditions the mole fraction on plate n is identical with that on plate n + 1, as represented by the following equation:

$$V_{n+1} Kx = L_n x + Dx_D \quad . \quad (39)$$

This equation is simply a material balance around the top of the column below plate n for conditions corresponding to the same composition of the particular component on plates n and n + 1 as for the zone of constant composition described. At this point in the column all components not present in the overhead distillate will have been rectified from the vapors rising from the feed plate, so that only those components will be present as are present in the overhead distillate. Therefore equation (34) also applies to this plate when used in connection with all components present in the distillate.

We therefore have two equations, (34) and (39), to determine the two unknowns, K and x for each component, for any particular minimum reflux. Under such conditions where D, L, and V are determined by the assumed minimum reflux, and x_D is known from the material balance there are only two unknowns for each components, K and x, and there can be only one solution that will fulfill the requirements of equations (34) and (39).

This computation of the temperature and composition for those plates of constant composition may be made clear by the following example based on the material balance of Table 9.

The first step is to assume a value for the minimum reflux ratio, $\frac{L}{V}$, or reflux L per mole of feed. Based on one mole of feed as shown in column 2 of Table 9, there will be 0.408 moles of distillate. Assuming a value for liquid reflux of 0.65 moles, the moles of vapor will be $0.65 + 0.408 = 1.058$ and the ratio $(L/V)_{min.} = 0.615$.

If the mole fraction of normal butane in the overhead distillate were zero, it follows from equation (39) that the value for K would be equal to (L/V), which in this case is 0.615.

Actually the value for x_D is not zero, and the value for K will be slightly larger than L/V. This relationship, however, may be used as a guide for estimating the temperature on the plates of constant composition whenever the mole fraction of the less volatile cut component is small in the overhead distillate. If we assume that the value for the K of normal butane is approximately 0.62, a temperature of 160°F. is indicated for these plates.

Using this temperature of 160°F., the mole fraction of ethane, propane, *iso*butane, and normal butane is computed using equation (39) on each of these components as indicated in Table 15.

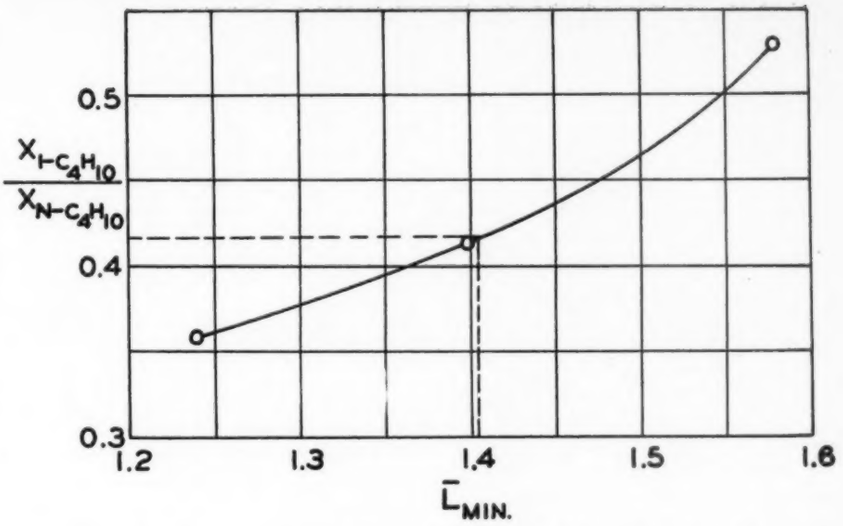


Fig. 18. Illustrating graphic solution of specific problem involving determination of minimum reflux required

As indicated in column 8, the mole fraction of normal butane is high, and a slight change in the temperature or equilibrium volatility constant for normal butane makes a relatively large change in the mole fraction of normal butane. Making this necessary adjustment, the composition on these plates is as indicated in column 9 of Table 15.

TABLE 15

Computation of composition of liquid in zone of constant composition above the feed plate for assumed minimum L = 0.65 and assumed temperature of 160° F.

1 Component	2 Moles in dist. per mole of feed Dx_D	3 K at 215 lb. per sq. in. abs. 160 °F.	4 KD	5 K-1	6 L (K-1)	7 (Col. 4 plus Col. 6)	8 x	9 Final value x
C_2H_6	0.0890	4.25	1.73	3.25	2.11	3.84	0.0232	0.0232
C_3H_8	0.2714	1.59	0.649	0.59	0.384	1.033	0.2625	0.2625
i-C_4H_{10}	0.0437	0.79	0.322	−0.21	−0.1366	0.1854	0.2360	0.2360
n-C_4H_{10}	0.0040	0.622	0.254	−0.378	−0.246	0.008	0.5000	0.4783
Total							1.0217	1.0000

The Approximate Minimum Reflux

This is the composition of the liquid that would be found on these plates of constant composition if the column were operated with a reflux ratio (L/V) of 0.615. It will be noted that the ratio of the mole fraction of the more volatile cut component, *iso*-butane, to the mole fraction of the less volatile cut component, normal butane, on this plate is 0.494, which is greater than the value of this ratio of the mole fraction of the two cut components in the liquid feed, 0.416, as has been mentioned. Although it may develop that the L/V of 0.615 is close to the minimum reflux ratio, the fact that the ratio between the cut components on the plate of constant composition is greater than the ratio between these components in the liquid part of the feed indicates that a greater reflux might be required as a minimum to effect the desired separation given in Table 9. Similar calculations to those shown in Table 15 give the values for L and the corresponding ratio ($x_{i\text{-}C_4H_{10}} / x_{n\text{-}C_4H_{10}}$) as shown in Fig. 17. By drawing a smooth curve through these points as indicated, the value for L = 0.727 (L/V = 0.641) is the minimum reflux necessary to reduce the ratio between the cut component to the same value in the zone of constant composition as in the liquid part of the feed. This value of $(L/V)_{min.} = 0.641$ so calculated is the approximate minimum reflux of Martin and Brown. (Trans. Amer. Inst. of Chem. Engrs., Vol. 35, No. 5, Oct. 25, 1939). This approximate method neglects the fractionation that may be obtained between the plates of constant composition and the feed plate due to the presence of the less volatile components on these plates although they are not present in the overhead distillate. This value of L/V = 0.641 is somewhat higher than the true minimum reflux but may be used in estimating or calculating fractionating columns because the small error involved is on the safe side as the reflux so computed is slightly greater than the actual minimum.

Calculations in the Stripping Section

If the more difficult separation, or the greater number of plates were in the stripping section, the approximate minimum reflux would be computed by calculations in the stripping section by a manner similar to that which has been described for the rectifying section.

By use of a similar material balance around the bottom of the column we have equation (40):

$$\overline{L}_{m-1}x = \overline{V}_m Kx + Bx_B \quad . \quad . \quad . \quad (40)$$

which may be used in conjunction with equation (35) in the manner outlined in Table 16 to obtain the composition in the zone of constant composition below the feed plate. In the bottom part of the column the temperature in this zone of constant composition may be estimated for any value of $\overline{L}$ in a manner similar to that used for the rectifying section. If the mole fraction of the more volatile cut component in the bottoms is zero, then in the zone of constant composition K will equal $\overline{L}/\overline{V}$. In this separation the mole fraction of *iso*butane in the bottoms is relatively large, and the value of K for *iso*butane in the zone of constant composition is appreciably less than $\overline{L}/\overline{V}$, which is 1.56, corresponding to 0.615 for L/V in the rectifying section. After a couple of tries using temperatures of about 230°F., the correct solution as given in Table 16 indicates a value of K for *iso*butane of 1.425 and a temperature of 228.5°F.

TABLE 16

Computation of composition of liquid in zone of constant composition below the feed plate for assumed minimum $\overline{L} = 0.65$ and assumed temperature of 160°F.

1 Component	2 Moles in bottoms per mole of feed Bx_B	3 K at 215 lb. per sq. in. abs. 228.5 °F.	4 KB	5 1-K	6 $\overline{L}$ (1-K)	7 (Col. 4 plus Col. 6)	8 x
i-C_4H_{10}	0.0368	1.425	0.8445	—0.425	—0.701	0.1435	0.2565
n-C_4H_{10}	0.1895	1.155	0.6845	—0.155	—0.256	0.4285	0.4420
i-C_5H_{12}	0.0732	0.68	0.403	0.32	0.528	0.931	0.0786
n-C_5H_{12}	0.1208	0.563	0.334	0.437	0.721	1.055	0.1143
C_6H_{14}+	0.1716	0.118	0.070	0.882	1.46	1.53	0.1120
Total...							1.0034

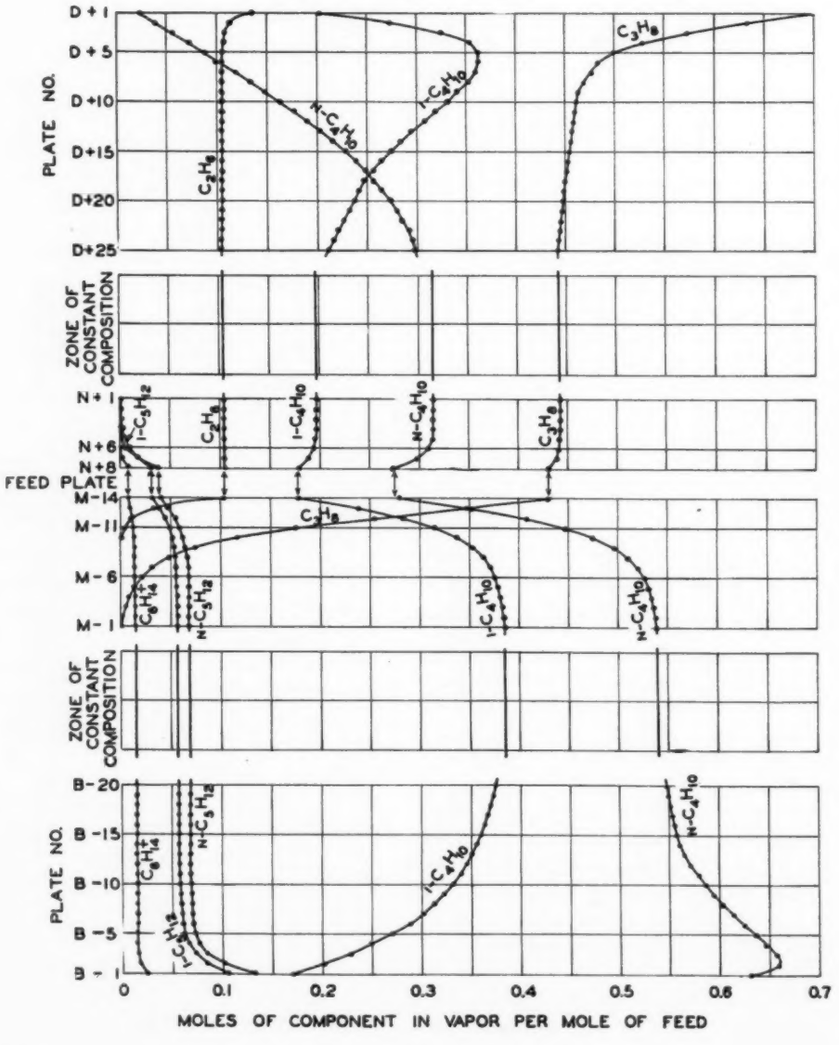
In a similar manner by assuming different temperatures, or different values for $\overline{L}$ per mole of feed, values for the ratio of *iso*butane to normal butane $\left(\frac{x_{i\text{-}C_4H_{10}}}{x_{n\text{-}C_4H_{10}}}\right)$ in the liquid were calculated for different values of $\overline{L}$ as plotted in Fig. 18. By drawing a curve through these points, the value for $\overline{L}$ giving a ratio of 0.416 is determined as 1.403. It will be noted that this value for $\overline{L}$ is not consistent with the approximate minimum $L = 0.727$ computed by Fig. 17 as:

$$\overline{L} = L + F_L = 0.727 + 1 = 1.727$$

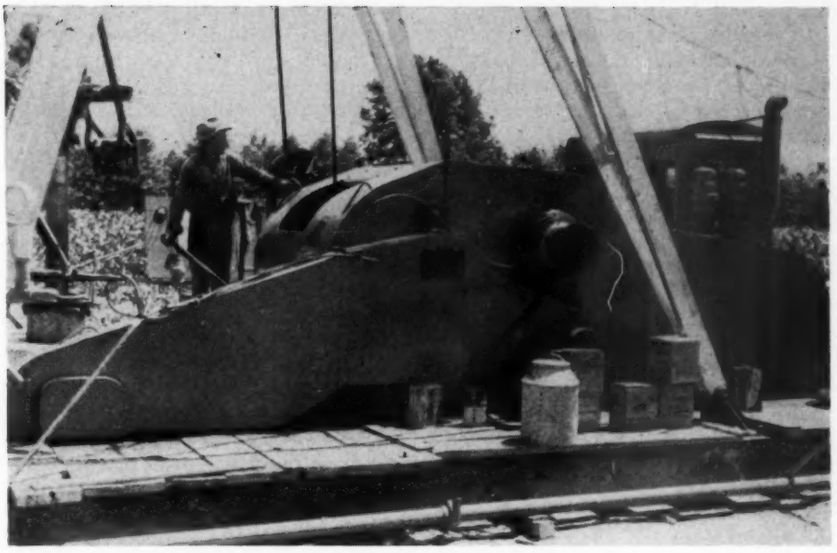
For reasons that have been described the approximate minimum reflux must be computed in that part of the column making the more difficult separation. In the separation of Table 9 the more difficult separation is made in the rectifying section. The calculation made in Fig. 18 is, therefore, not a calculation of the approximate reflux but simply an example of how such a calculation would be made if the more difficult separations were in the stripping section.

Fig. 19 was computed by plate-to-plate calculations except in the zones of constant composition assuming a constant reflux ratio within the column. The details of this computation for Fig. 19 and the calculation of the exact minimum reflux will be explained in the next installment.

Fig. 19. Composition of vapors rising from plates in a column containing an infinite number of plates



Correction: The exponent in equation (38) should be $n + 1$ and not $n + 2$ as given on page 36 of the previous installment.



One of the newer types of streamlined drawworks drilling a well east of Burnt Prairie, Illinois

A PETROLEUM ENGINEER FEATURE

By
H. LEE FLOOD
Associate Editor

Illinois Area Is Showplace for Lightweight Drilling Equipment

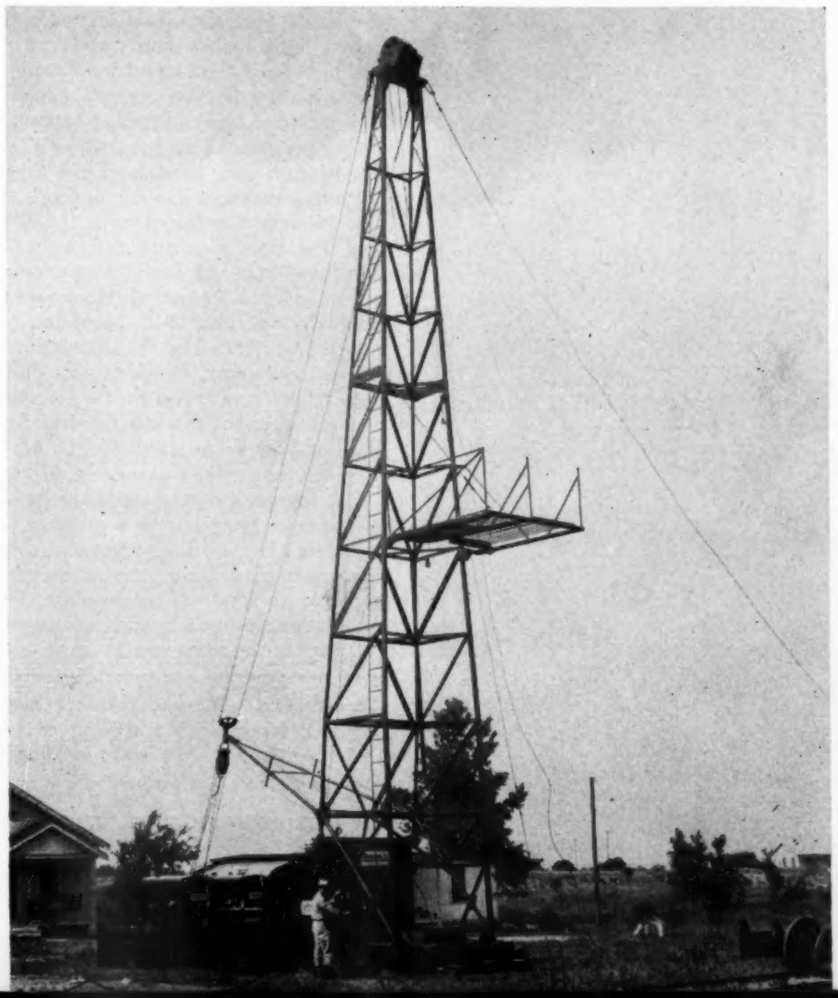
Shallow depth to producing formations has influenced trend to slim-hole equipment—boom may be over in Illinois but area will continue active

BEFORE discussing current drilling practices in the Illinois Basin it seems advisable to preface these remarks by a brief mention of some of the underlying factors that influence, intangible though they may be, the things that are done and the routes that are followed by the companies and contractors who are drilling in Illinois. It is important, too, to emphasize the fact that so many diverse elements are present in the entire picture that it is difficult to trace a pattern in the drilling procedure except only in the very broadest sense.

Not only is this diversity in practice influenced by the large number of individuals, each with his own slightly different version of how best to drill and complete a well, who are engaged in supervising the many drilling operations in Illinois, but also the different conditions in various parts of the Basin play an important part in dictating the varied practices being followed.

More important probably than any other factor as an influence on the manner in which drilling is conducted in Illinois and on the type of equipment that is being used is the matter of shallow depths. Coming into prominence as an oil-producing area at a time when the entire industry was concentrating upon the development of heavier and heavier equipment to drill still deeper than ever before, the Illinois Basin brought a demand for lightweight equipment in a volume that had not been equaled for years.

Two years ago when the Illinois activity was really getting under way,



This compact, portable derrick and machinery, recently purchased, is now busy drilling slim-hole wells in the Wabash River basin of Illinois

heavy and medium-heavy drilling equipment was moved into the area, partly because this was often the only size owned by many contractors and partly because at that time it was not known how deep the development might ultimately be.

Thus far, 2000 to 3000 ft. are the average depths to which most of the wells have been drilled. Even the more recent development of the Devonian limestone, referred to in Illinois as the "deep" drilling, has not required going to more than 3500 ft. Most of the talk at present, particularly in the Salem-Lake Centralia and in the Centralia fields is concerned with whether the Trenton limestone of Ordivician age may prove productive in these areas. Even in drilling to this formation, if found productive, it is probable that the total depths will not exceed 4000 ft. Whether any formations below the Trenton will prove to be productive, is not yet known nor even anticipated.

Lightweight Rotary Equipment

The drilling equipment in use in Illinois fields at the present time is predominately of the lightweight, easily moved type generally classified as slim-hole or streamlined equipment. Many of these drilling outfits are of the type that are mounted on a single frame that may be winched-on a truck and readily moved as one piece. A machine of this type, only recently purchased, is shown in Fig. 1.

Occupying an equally important position in the Illinois drilling picture at the present time are the truck-mounted portable masts and drilling machinery generally classed as being of the core-drilling type. The manufacturers who specialize in building this type of equipment have strengthened and enlarged the units until the present models are capable of drilling to 3000 ft., in some instances deeper, without difficulty. One of these machines, recently purchased and now at work in the Wabash River area of southeastern Illinois, is shown in Fig. 2.

Another machine of this type, drilling in the Keensburg pool, eastern Illinois, is shown in Fig. 3. This unit has drilled 16 oil wells during the last 18 months and has served satisfactorily under the conditions encountered.

Spudders

The Illinois Basin has probably supplied the greatest impetus to the intensive improvements that have been made in recent years in the spudder-type machine. Several entirely new designs in spudders introduced by various manufacturers recently are now being used extensively in the Illinois fields.

The general practice, right from the beginning of the Illinois activity, has been to drill down with rotary equipment to the top of the producing formation, set and cement casing, move out the rotary equipment, and then move in a spudder to drill-out the plug and complete the well, or "tail-in," as the operation is generally termed.

Deepening Program in Salem Field

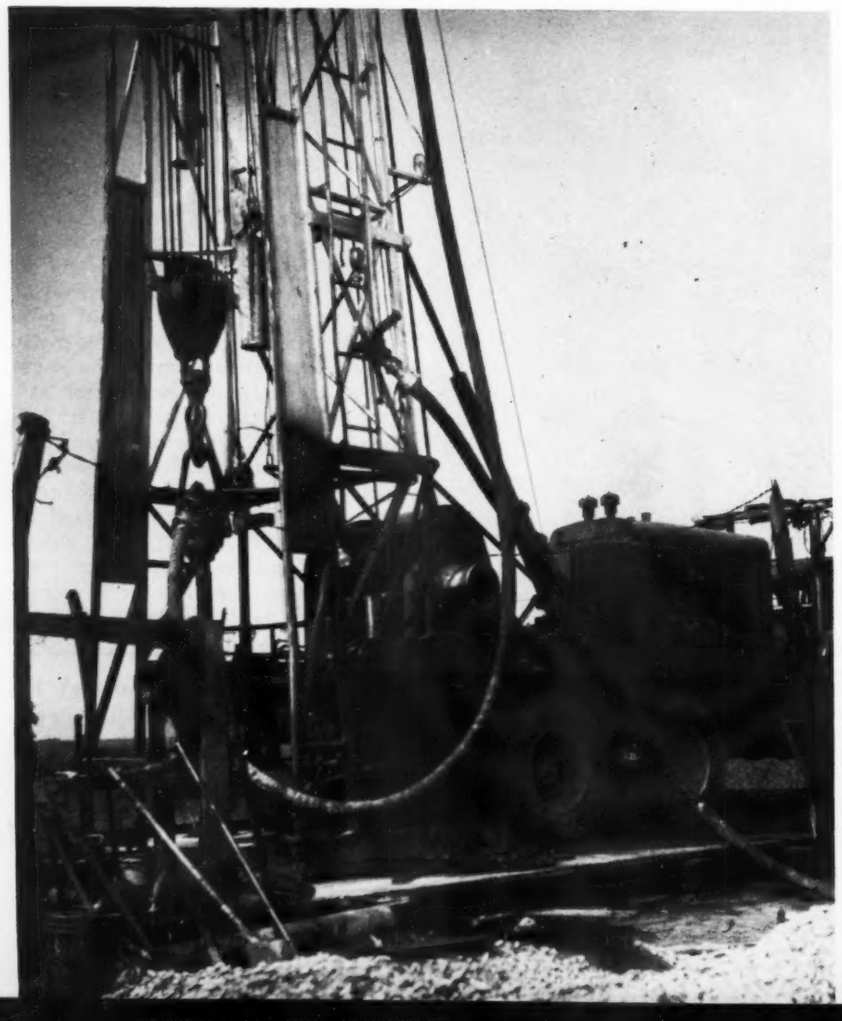
Greatest activity at the present time is probably in the deepening operations currently in progress in the Salem field by The Texas Company and, to some extent, by other operators.

The principal producing formations exploited in the Salem-Lake Centralia area thus far have been the Benoist formation in the Bethel sandstone in the Chester series of Upper Mississippian age, the McClosky "sand" in the Fredonia limestone of the Iowa series, and, more recently, the Devonian limestone, from which prolific production has served recently to increase the state's production to more than 14,000,000 bbl. per month.

Beginning only recently, however, wells completed in one or another of these three formations are now deepened to a lower producing sand or limestone. There is no fixed rule about the procedure and a given well may be completed in one of several deeper formations, depending upon the volume of production found. Benoist wells may be deepened only to the Aux Vases sandstone, or may be deepened to the McClosky, St. Louis, Salem, or Devonian—all limestones.

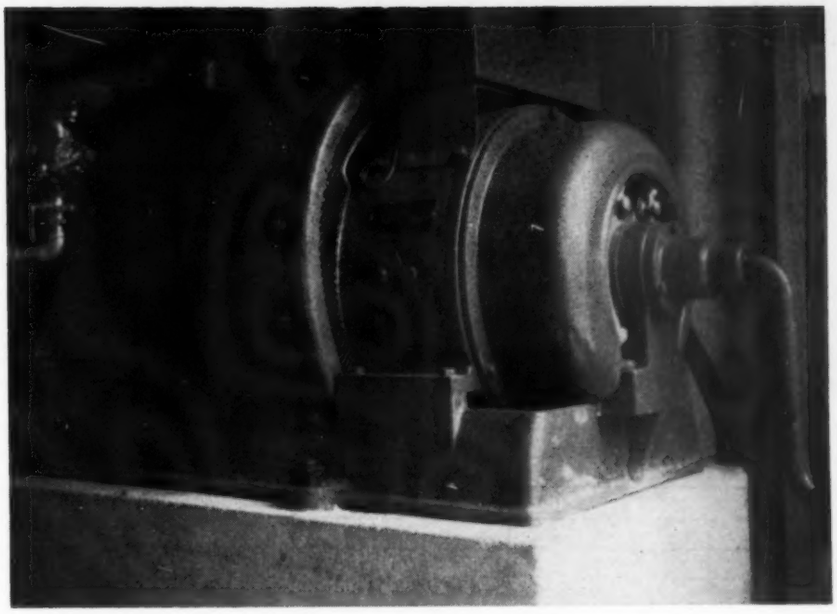
This deepening program is going forward at a rapid rate and virtually every lightweight machine capable of drilling a hole seems to be at work carrying out these deepening operations. Being used are all types of spudders, including shiny new machines of the latest type as well as scarred veterans; light mobile hoists and masts, and lightweight drawworks where production-type derricks are still erected.

Concern is being expressed by many drilling contractors in Illinois at the present time because of the drastic curtailment in drilling during the last 30 days. Compared with the 399 and 391 completions during the months of May and June, 1940, respectively, only 279 completions were made during July, 1940, according to figures just released by the Illinois State Geological Survey. Probably this drop does reflect a cessation of the flurried activity that has marked the area for the last year or so. It should be kept in mind, however, that nearly all the major companies operating in the Basin will require from one to two years to complete their drilling programs and, consequently, drilling activity may be expected to level off at possibly 200 completions a month and remain at this rate for another year at least.



Core-drilling units like this are now veterans in the drilling of oil wells in Illinois

Gas-engine-driven cathodic protection units of 2000-watt capacity were installed



By
H. C. GEAR
Assistant Engineer
Lone Star Gas Company

Careful Cost Study Leads Gas Company to Selection of Cathodic Protection

Forecast of future expenditures for maintenance of line indicates electrical protection will pay dividends in highly corrosive area

THE Lone Star Gas Company's first experiment with cathodic protection of pipe lines is now under way in a pipe-line district that presents one of the worst corrosion problems on the system. The maintenance experience of the company has developed the fact that external corrosion is not uniformly distributed, but is confined to relatively small sections of individual lines. After repairs on these sections become necessary, there is an instant increase in the number of repair jobs with the result that the maintenance cost of a corroding section of line becomes a consistently greater item of expense each year.

The section of line selected for cathodic protection is near the town of Electra, Wichita County, Texas. This 18-in. coupled line was laid in 1927, and was coated with one of the standard brands of paint. The corroded section traverses 3½ miles of rolling pasture land. The character of the soil changes frequently, the most general types being what are commonly called "red bed," dense clays that vary in color from light yellow to brown, mixtures of shales, and areas flooded by seepage from salt-water pits. Resistance measurements made on saturated samples range from 800 to 3000 ohms per cu. cm. The scales formed vary from a bright yellow to the common red and black oxides.

H. C. GEAR

received his education from Texas A. and M. College and the University of Colorado—Entered employ of Southwestern Bell Telephone Company in 1928 and was with that company for one year—Became affiliated with Lone Star Gas Company in April, 1929, first in the valuation department—After a year's service was transferred to the engineering department—Is an assistant engineer.

Beginning with the year 1930, a fairly complete record of pipe-line repairs and replacements has been kept. In cases where the repairs or replacements are due to corrosion, the repairs or replacements are plotted on a strip across the alignment maps opposite the points at which they occur. By the use of this method the location and trend of corrosive areas are readily defined. Although separate symbols are used for each type of repair, the criterion is the location and frequency of the necessary repairs or replacements. By referring to Fig. 1 the graphic significance of this method is readily observed. A correlation of these data is made by plotting the cumulative total repairs against calendar years, or service age, on log log coordinate paper. From the data shown in Fig. 1, a straight-line relationship results if the six repairs that were made in the year 1931 are disregarded. The algebraic equation expressing this time-repair relationship is of the form $Y = ax^n$, when x is the total number of repairs to date corresponding to service age y years, n represents the corrosive index or slope of the curve, and a is the proportionality constant. Although this formula is purely empirical, it is an excellent means of extrapolating historical data once the trend has been definitely established. Perhaps in time the relationship of x and y may be arrived at by dimensional reasoning, but for the present

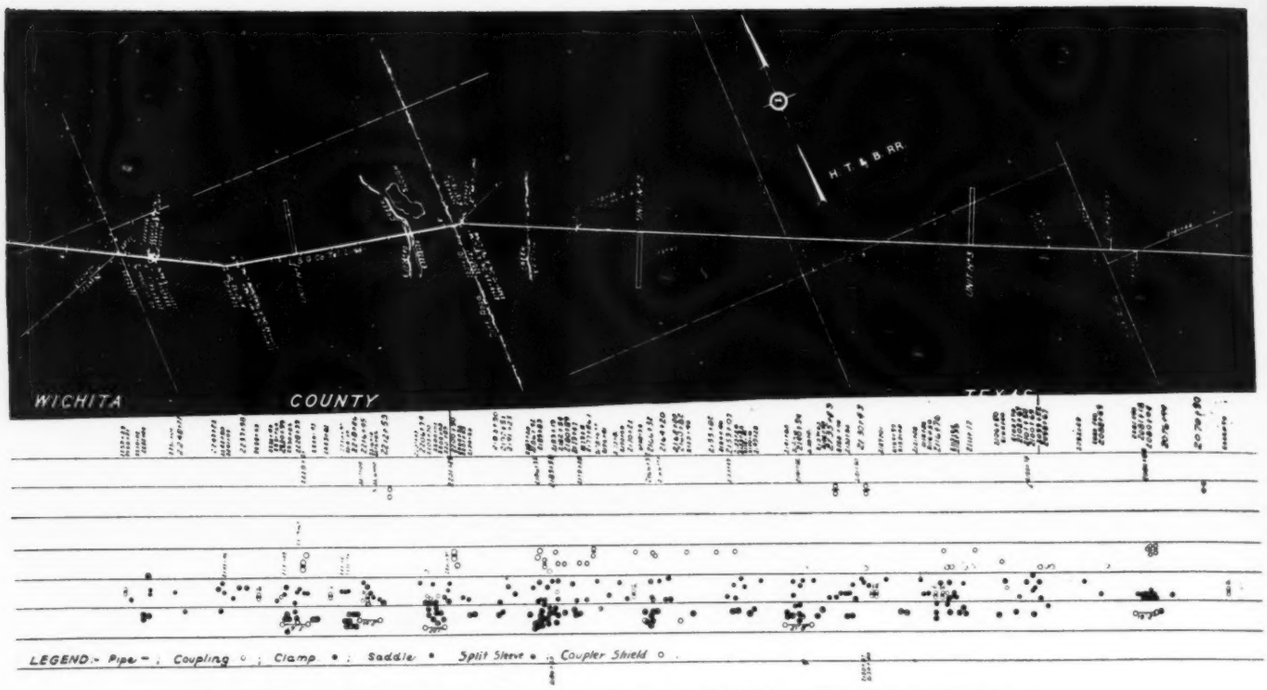


Fig. 1. Record of repairs and replacements was plotted to determine corrosive areas

the constants a and n serve the purpose and embody a number of influential factors.

The list of individual repairs on this line ranges from $12 upward, depending upon the type of repair made; the average cost approximates $20. As shown by Fig. 1, during the last 2½-year period through the month of July the repair jobs totaled 278 at a cost of approximately $5,560. If the repairs increase at the rate indicated, it will no longer be economically feasible to maintain the line under these conditions. The cost of reconditioning this section of line, based on past experience, would be approximately $7,000 per mile, or a total of $25,000.

In view of the existing conditions, the company was confronted with three alternatives:

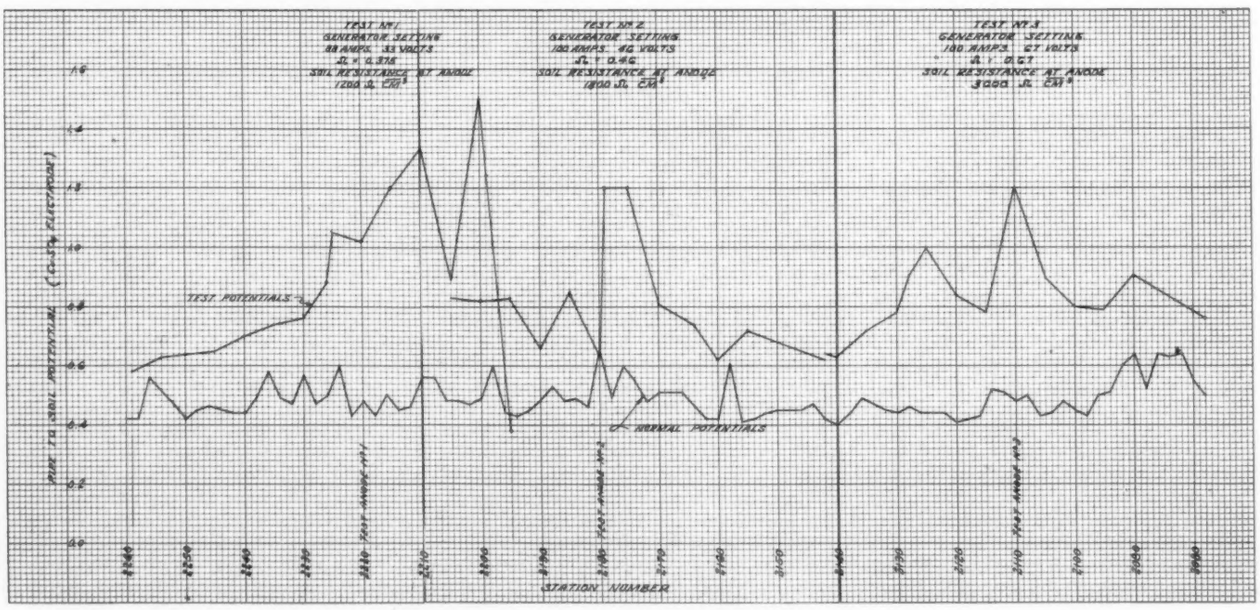
1. The extensive use of clamps, saddles, split sleeves, and replacement joints as they are required.
2. Reconditioning all the old pipe so far as possible, replacing those joints that are beyond repair.
3. The installation of cathodic protection.

The comparative value of any undertaking is in direct proportion to the economy of rendering the service. With the above situation the economic comparison is made between the total annual cost of each alternative.

The annual cost of repairs based on the 1940 experience amounts to $4,000, and this figure will successively increase with the passing of time.

To recondition the line by cleaning, spot welding pits, welding all joints

Fig. 2. Test potentials, from which locations of the permanent units were determined.



instead of replacing the couplings, coating and wrapping, relaying and testing, with such replacement joints as are necessary, would cost approximately $25,000. The trouble-free period of operation that may be obtained by the use of this procedure would approximate 15 years. Under this assumption the annual amortization charges at 6 percent interest amount to $2,575. With respect to the selection of cathodic units, the gas-engine-driven type was considered; mainly because of the constant current output, the available fuel supply, the larger capacity, and the absence of electrical transmission facilities. Included in the cost of installing the cathodic units is the bonding cost due to the fact that the line is coupled. The service life of the gas engine units is estimated at ten years. On this basis, at an installation cost of $7,000, the annual charges are as follows:

Amortization charge (10 yr. at 6 percent)	$ 951.00
Quarterly inspection and testing	300.00
Replacement parts	30.00
Attendance	240.00
Oil	10.80
Fuel gas	78.80
Total	$1,609.60

These estimated costs resolve into the following comparative figures:

Alternative	*Investment*	*Annual cost*
1. Repairs and replacements made as necessary	.....	$4,000.00
2. Reconditioning, 3½ miles of pipe line	$25,000.00	2,575.00
3. Cathodic protection	7,000.00	1,591.80

Allowing corrosion to continue unabated is not meeting the issue and this policy would be the most expensive of all from the standpoint of operating cost. This procedure would lead to the increased hazard of exposure in making repairs, the eventuality of blowouts during peak demand periods, and the possibility of adverse legislation.

Experience with cathodic protection has been so satisfactory[1] that there is no longer any question concerning the results to be obtained by its proper application. For our particular problem, it was decided that the investment required and the annual operating charges would be so greatly reduced by the installation of cathodic protection units that this alternative was the only one to adopt.

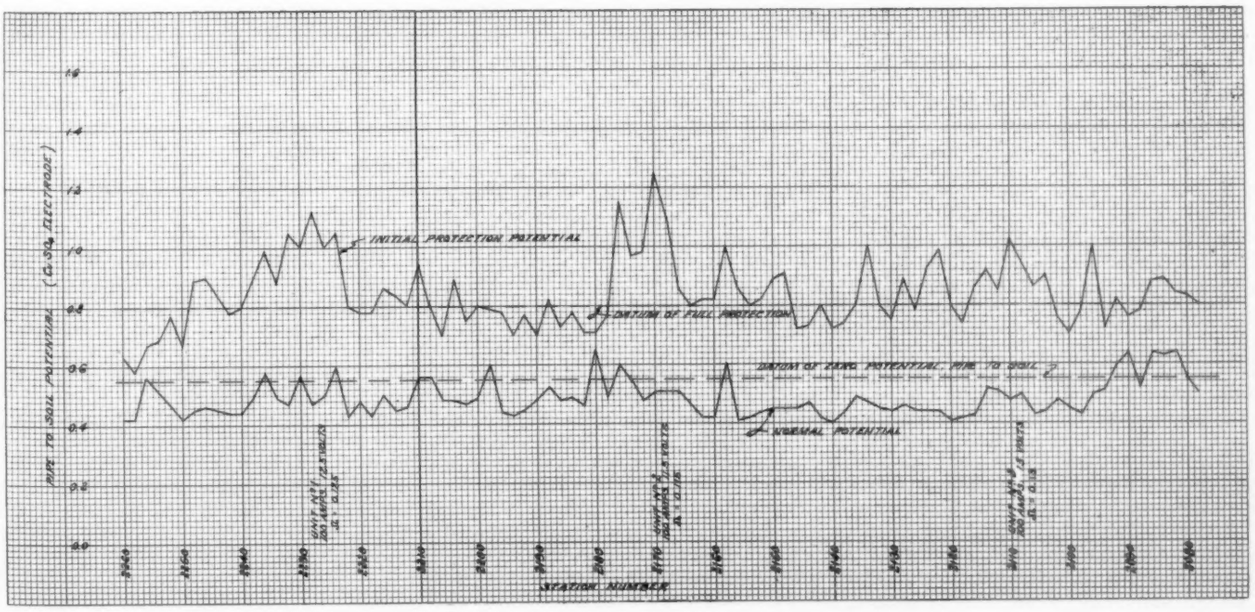
In the last several years a wealth of information has been published relative to cathodic protection technology. It has been through these channels and the research conducted by the corrosion sections of the American Gas Association, the American Petroleum Institute, and the U. S. Bureau of Standards that this phase of engineering has reached its present state of perfection. From a practical standpoint, however, every cathodic installation is a separate problem that has its individual characteristics.

[1] "Cooperative Problems Involved in Cathodic Protection," by L. F. Scherer. Paper presented to the group session on pipe line transportation problems under the auspices of the Division of Production of the 20th Annual Meeting of the A.P.I., Chicago, Illinois, November 16, 1939.

In order to determine the current requirements and the location of the cathodic units, tests were conducted with a welding machine at three tentative locations. Prior to testing the sections of line to be protected it was necessary to bond all couplings. The pipe as originally installed consisted of random length joints and the use of many "pup" joints in replacements added to the difficulty of locating the couplings. In some instances this could be done electrically by measuring resistances; however, due to the difficulty of barring the pipe and to contact trouble most of the couplings were found by digging at the normal interval and stripping until the coupling was found. There were a number of instances when resistance measurements failed due to the fact that the couplings were "iron bound." This task was accomplished in two weeks, however, the number of couplings stripped being 961. Each man excavated 8 couplings per 10-hour day on an average.

The bonds consisted of a 23-in. length of No. 4-0 solid, soft-drawn copper wire and bent to contact the pipe at each end and the center ring. These bonds were installed by draining the section of line and carbon arc brazing to the pipe and center ring using a ⅛-in. phosphorus bronze filler rod. The welding crews consisted of welder, welder's helper, driver, and a workman to clean the pipe and center ring. A pair of long-handled tongs were used to hold the wire bond in place during the welding operation.

Fig. 3. Potential survey taken after the units had been in operation 10 days



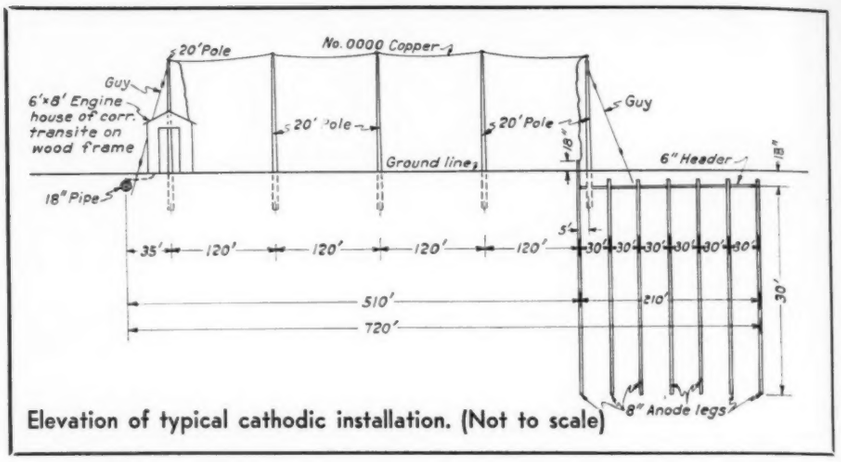
The negative generator lead was connected to the tongs. The welding machines were 200 amp. units mounted on "pickup" trucks and three crews were used. The actual welding time was 18 hours.

Three test sites were selected using two joints of 18-in. pipe as the anode and a 300-amp. welding machine for a source of current. The test potentials are shown in Fig. 2. The sharp change in potential shown between station 2195 and 2200 was due to an unbonded coupling—apparently the only one that was missed. The sudden drop between station 2179 and 2180 is possibly due to the fact that the test anode was placed in a creek bed crossed by the line at this point.

From the data shown in Fig. 2, the permanent units were located. The deductions made from the test data were arrived at by shifting the curves east or west as the occasion demanded. When two units were working together on the same section of line the cumulative effect of the rise in potential caused by each unit was calculated. The test anodes were spaced 400 ft. from the line and excessive potentials resulted at each test site. This indicated that a great power saving could be accomplished by placing the permanent units farther back from the line. The permanent anodes were placed 500 ft. from the line. Unit No. 1 was moved 800 ft. west of the test site, Unit No. 2 was moved 1000 ft. east, and Unit No. 3 was not changed.

The anodes are each of the vertical type, and consist of 8-in. vertical legs 30 ft. long, spaced 30 ft. apart, and tied together by a 6-in. header. The vertical legs are slotted, the 6-in. header is welded to the 8-in. with "weep" holes at every connection. The entire system is made up water tight and provided with a connection on the end riser to allow the addition of a brine solution. In the case of a resistance increase due to drying, brine can be added. The top of each 8-in. leg is covered with a piece of creosoted lumber. Should these pipes eat away as they will in time, a smaller diameter pipe may be inserted or possibly the addition of powdered coke may revive this section of the anode. As to plan, the anode is laid-out in a straight line perpendicular to the pipe line. The vertical 8-in. pipe was set in 10-in. holes drilled by a coring machine; the 6-in. header is laid in a trench 18 in. deep, and the backfill conceals everything but the end riser.

The sources of direct current are three natural-gas engine cathodic pipe line protection units. These units have a 2000-watt capacity with a top output of 100 amp., and a voltage range from 5 to 35. The units are set on concrete foundations and are housed in corrugated transite buildings 6 ft. 10 in. by 7 ft. 4 in. by 6 ft. high. Fuel is supplied at a pressure of approximately 10 in. water column.



Elevation of typical cathodic installation. (Not to scale)

The positive feeders to the anodes are of No. 4-0 stranded bare copper wire strung on 20-ft. creosoted poles spaced 120 ft. apart.

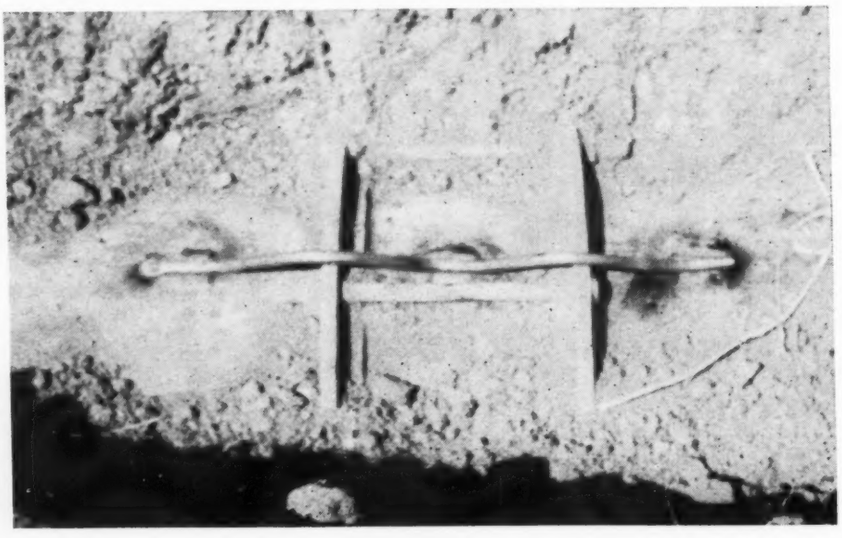
From the potential survey taken after the units had been in operation ten days, (Fig. 3), a very flat potential curve has been obtained. There is very little waste of power. There are several short areas that do not have what is generally considered full protection. It is hoped, however, that as the line becomes polarized these areas will undergo a rise in potential. At present the moisture content at pipe depth is low but possibly during the fall and winter as this moisture content builds-up, the hoped-for increase will be realized.

This section of line is patrolled twice each week and it is now the linewalker's duty to check the units on his biweekly rounds. He is instructed in the operation of the units and is prepared to make any minor adjustments necessary. A record of the operation of each unit is carefully made. Amperage and voltage readings, speed measurements, fuel and oil consumption, and cooling water are all checked and anything out of the ordinary noted. The time required to make these observations is about 15 minutes for each unit and will not add greatly to the cost of attendance.

The resistance of each circuit is slightly less than was anticipated and the resultant load on the units range between 1150 and 1300 watts. This is a little more than 50 percent of the rated output and should add to the life of the units. At present the cost of power based on fuel and oil alone is 0.384 cent per kw-hr.

Much valuable assistance was derived through the association with Starr Thayer, consulting engineer, Houston, Texas, who coöperated in the design of this installation.

Pipe joints and couplings were bonded in this manner



The Technology of Refining Processes

Article 8

Solvent Dewaxing, Deasphalting, and Deresining

By

ARCH L. FOSTER

The Lubri-Zol Corporation, Cleveland, Ohio

DEWAXING paraffinic lubricating oil fractions to reduce pour point to a temperature practicable for easy starting of automotive and similar equipment exposed to widely varying temperatures has always been one of the refiner's serious problems. The problem first assumed really large proportions when automobiles became reliable enough to permit their operation during cold weather.

It is not possible here to more than mention the older methods employed for removal of paraffin waxes from Pennsylvania, Mid-Continent, and similar lubricant fractions. The first process generally used was cold settling. A tank, usually cylindrical and of any desired dimensions was fitted with cooling coils through which cold brine or other liquid, chilled by exchange with expanding ammonia or other refrigerant, was passed. These coils were submerged in the wax distillate, circulation of the cooling medium was started, and the oil slowly chilled while remaining in a quiescent state without any other motion except that caused by convection currents set up by differences of temperature in the tank. The crystallized wax formed and settled slowly to the tank bottom as the temperature of the mixture declined below the solidifying point of the wax present. It was eventually drawn off at the bottom, after the partly wax-free oil was pumped from the tank.

The next process to be adopted was removal of solidified wax from the chilled oil by pumping the semi-solid wax-oil mass through filter presses; the perforated metal "leaves" of the press are covered with heavy duck or other fiber or metal cloth that retain the solid wax but permit the dewaxed oil to pass through. This process is still widely used, although it has been in great measure superseded by more efficient methods. One of the problems of the refiner was to bring the wax distillate to the press in such condition that it would filter well, giving good separation of oil and wax. This calls for careful chilling methods, carried out slowly enough that large wax crystals are formed rather than a relatively larger number of small crystals. The small crystals do not permit easy passage of the oil and form an unctuous mass on the filter cloth. The result is a low rate of filtration, an excessive back pressure, and a wax cake that contains entirely too much oil, increasing sweating costs and reducing yields of dewaxed oil. A very careful technique has been worked out for the control of the crystallization characteristics of wax distillates, to produce large crystals, promote complete crystallization, and yield low pourpoint oils and low oil loss in the crude scale wax. (E. A. Burch, *Proc. A.P.I.*, Nov. 14-18, 1938; *National Petroleum News*, Nov. 30, 1938, p. R-582).

The chief problem with operation of these older processes is that production of very low pourpoint oils is a very difficult or at least impracticable accomplishment. Newer methods have been developed that are more expensive in first cost of installation but which make it an easier matter to refine oils with pour points below zero Fahrenheit to meet the requirements of present-day market demands. One of these is the so-called supercentrifuge process that came into wide use some 15 years ago and is still widely used, especially for the removal of "amorphous" or low melting point wax from heavy residuals or the heaviest overhead oils.

This method utilizes the difference in specific gravity of solidified wax and of the oil diluted with one or more volumes of a special, closely-fractionated naphtha, and the important item of equipment is the supercentrifuge. This latter instrument had been developed earlier for the purpose of separating fat content of milk but was more highly specialized and its speed increased for the separation of paraffin wax and oil mixtures. One of the grave problems to be overcome was that the wax, after being separated from the oil in the centrifuge bowl at rotational velocities of 17,000 r.p.m. or higher, closely adhered to the surface of the metal bowl, soon clogging the machine and stopping operations. This was solved by the introduction of warm water into the machine at a point immediately after the wax separates from the oil; the heat melts the wax, which is then

ARCH L. FOSTER

after receiving bachelor's and master's degrees in organic chemistry from the University of Texas in 1922 became affiliated with the research and development division of the Gulf Refining Company, where he remained until 1925—From 1925 until 1929 he was with the Petroleum Division, U. S. Bureau of Mines, at San Francisco, California, in charge of the chemical research laboratory—During the period, 1927-29, he was assistant to the chief engineer, Petroleum Division, Washington, D.C.—From 1929-39 was technical editor of *The National Petroleum News*, Cleveland, Ohio—In 1939 joined the staff of The Lubri-Zol Corporation as sales engineer, having as his field of activity lubricants and lubricant-treating methods.

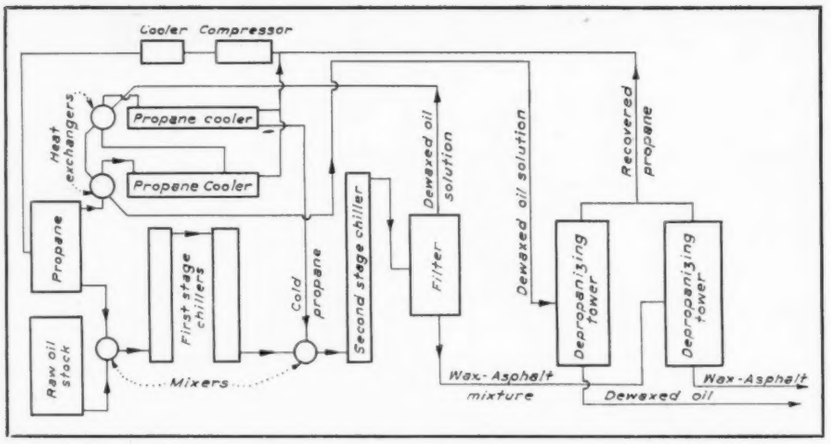


Fig. 1. Flowchart of continuous propane dewaxing, deasphalting, deresining process for lubricating oils

continuously thrown from the machine as a water-liquid wax mixture and this is separated later for recovery of the wax or "petrolatum."

Oil-wax temperatures, rates of flow, concentrations of wax in oil, and amounts of naphtha employed vary so widely that specific data can hardly be given that could be considered typical of this operation. Naphtha may be added to the undewaxed oil in ratios of from 1:1 to 4:1 or even more, depending on the amount of wax present, the temperature employed, and the pour point desired in the finished oil. Normally the waxy distillate or residual oil is chilled to a temperature 10° to 15°F. below the pour point desired in the dewaxed oil. The recovered wax may be refined to petrolatum or paraffin wax, may be cracked to produce gasoline, or utilized in numerous special products from the refinery.

Solvent Removal of Wax, Asphalt, and Resins

More recently the application of solvents, or what may be called precipitants, has been perfected for the removal of paraffin waxes, asphaltic bodies, and resinous impurities from lubricant fractions, and most of the dewaxing capacity built during recent years—since about 1933—has been of this type of process.

Many solvents have been studied for application to this problem, but commercial practice has settled down to two combinations in nearly all units now operating. Trichlorethylene has been used to some extent, but the two main solvents for wax removal are propane, and mixtures of benzol with various ketones such as acetone (dimethyl ketone) and methylethyl ketone.

The principle involved in the removal of wax, asphalt, and resinous products from lubricants is that of the comparative solubility of oil and of these impurities in propane solution at low temperatures. Propane is more widely used than any other solvent, probably for two reasons: (1) it is or may be produced in the refinery or natural gasoline plant at low cost with correspondingly low cost for replacement of solvent losses, and (2) it is its own refrigerant. All or most of the refrigeration required in a propane dewaxing plant may be supplied by simple evaporation of excess solvent, by reducing the pressure on the solution at rates of cooling that are known by experience to produce the desired precipitation of impurities. The excess solvent may be added to the waxy oil in such quantity as is found by experience to be necessary to obtain the required refrigeration; or, precooled propane may be added to the chilled solution after evaporation or indirect means has accomplished the chilling.

Propane is a satisfactory solvent for paraffin wax at ordinary temperatures, as well as for the desirable oil constituents of the lubricant fraction. When the temperature is reduced, however, in a propane-oil solution in ratios of two parts of propane to one of oil, or even in 1:1 ratio, the wax is selectively precipitated or crystallized, leaving the oil in solution, along with most of the asphaltic and resinous bodies present. By careful control of the rate of pressure release and, therefore, of evaporation and of solution chilling, it is practicable to attain a rapid rate of chilling and at the same time to form a large-crystal wax structure that is easily filtered with minimum oil losses in the wax (Bray and Bahlke, *Proc. Amer. Chem Soc.*, August, 1935). The earlier units designed to dewax with propane employed batch type filters, which could be placed on the "line", filled with wax to a given deposit thickness or a predetermined back pressure, the wax forced off the filter leaves by reverse flow of an inert gas, the dumped wax discharged from the bottom of the press, and the chilled solution pumped through again, all without opening the press. More modern filters are of the continuous type, as will be discussed later.

Before going into details regarding dewaxing, deasphalting, and deresining with propane, a discussion of some of the properties and effects of this solvent is in order. Propane was first applied to the removal of asphaltic materials from heavy residuals in order to refine them more satisfactorily without distilling them overhead. At that time, distillation of the heaviest components was considered to be impractical and to be the cause of deterioration in essential qualities. (Bray and Bahlke, loc. cit.). Propane has a much higher solvent effect on the more paraffinic oil components of lubricating fractions than it has on aromatic constituents. This appears to be a contradiction inasmuch as propane also selectively precipitates paraffin wax from mixtures with the oil components. It is more understandable, however, if we realize that the so-called "paraffinic" portion of lubricants is not paraffinic in the strict sense at all, but as Rossini has found (Publications, U. S. Bureau of Standards, on A.P.I. Research Project No. 6) the best lubricant fractions are composed of naphthenes, i.e., polynuclear molecules that may or may not be combined with aromatic nuclei. Paraffin wax as such is a definite and distinct class of compounds in the heavier petroleum fractions, entirely different in molecular structure from those lubricating components that are usually referred to as paraffinic. Development of petroleum refining terminology before any actual knowledge of the chemical structure of the various components was available has resulted in this application of the term "paraffinic" to products that so far as we know have no structural relationship whatever to paraffin wax hydrocarbons. Our knowledge of this field of the molecular composition of lubricating fractions is still too meager, however, to support any dogmatic statements.

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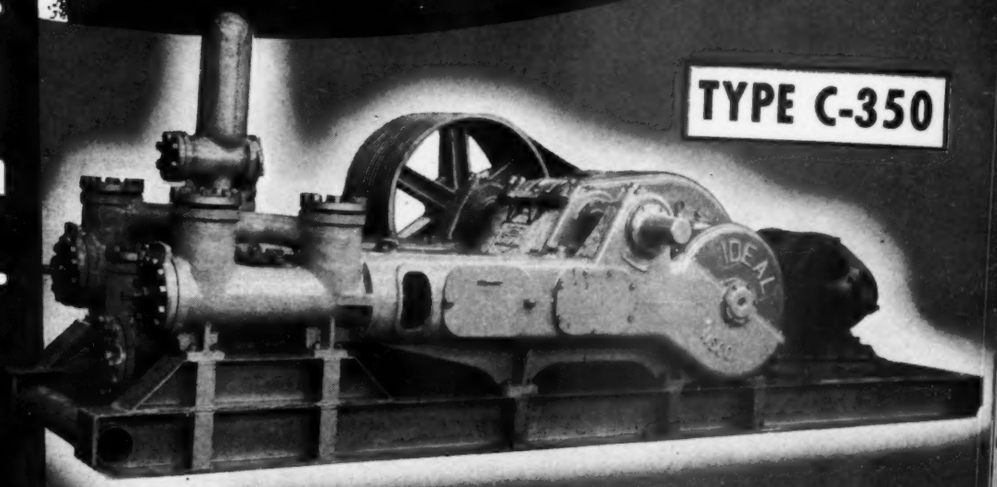
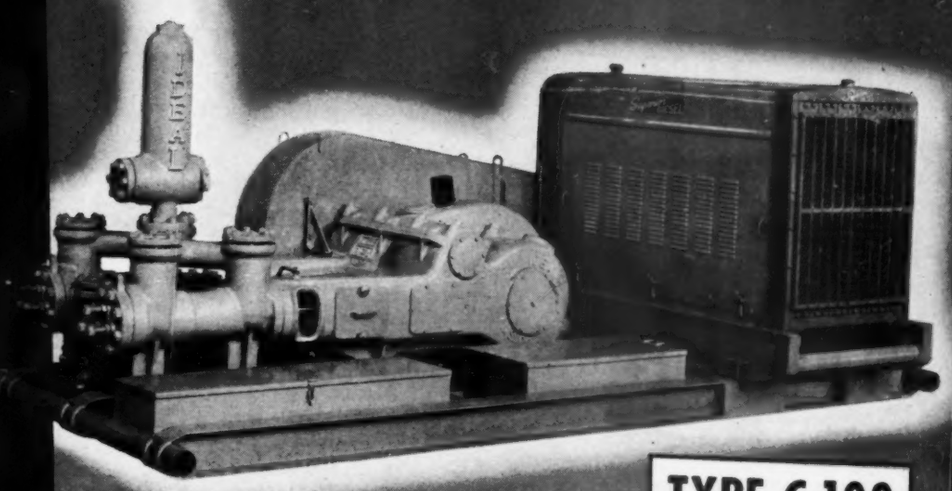


TYPE C-350



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BRIEF SPECIFICATIONS

MODEL NO.	MAXIMUM LINER SIZE	STROKE	MAXIMUM WORKING PRESSURE	PRESSURE RATING OF FULL-SIZE LINER	RATED SPEED	RATED HORSEPOWER	WEIGHT POUNDS
C-100	6½"	10	1,500	520	65	100	11,100
C-150	6½"	12	2,000	555	65	150	17,000
C-250	7¼"	15	2,500	710	60	250	28,975
C-350	7¼"	18	3,000	800	55	350	36,400

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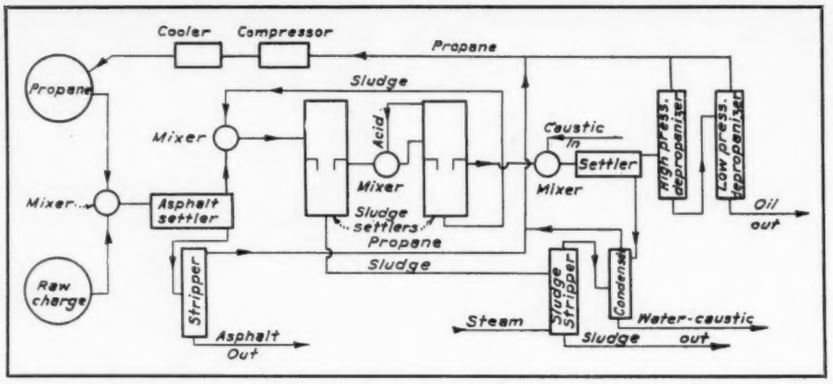

Fig. 2. Flowchart of continuous propane deasphalting-acid treating unit for lubricating oils

Experience has shown that treatment of an asphalt-containing heavy residuum improves the viscosity index by removal of the asphaltic material, and that the viscosity index of the extracted product is higher than that of a distilled fraction of the same viscosity from the same residuum. This is due in part to the removal of asphalt and in part to the wider distillation range of the treated fraction as compared to the distilled product.

In treating oils with propane, the oil-propane ratio and the temperature of the solution are the controlling factors. The suitability of propane for this purpose, as compared to other light hydrocarbons is shown by Bray and Bahlke. In treating a California long residuum (topped Poso Creek crude) with ten volumes of several hydrocarbon solvents, ethane removed 89 percent of the charge as "asphalt," yielding 11 percent of a 24.2 A.P.I. gravity oil having only 0.077 Carbon Residue. Propane under the same conditions removed 25 percent of the charge, yielding an oil of 17.5 A.P.I. gravity, 94 seconds Saybolt viscosity at 210°F., and 2.35 carbon residue. A 1:1 mixture of propane and butane boiling from minus 42° to plus 46°F. extracted 12.7 percent of asphalt, the raffinate having 119 seconds viscosity at 210°F., but with 4.2 carbon residue. The butanes, pentane, and hexane removed decreasing amounts of asphalt as the molecular weight of the solvent increased, hexane extracting only 2 percent of the charge, leaving an oil having about 7.1 carbon residue.

Propane, therefore, has shown the most advantageous properties for this purpose as is attested by its wide adoption by the industry. The higher homologs show too high a solvent power for the asphalt, giving poor separation and rejecting little of the undesired material. Asphalt precipitated by propane appears to be more naphthenic and aromatic than that obtained by reduction of the heavy fraction by distillation. Researchers believe that this is due to the fact that some of the paraffinic materials that may be retained in the asphaltic bottoms because of extremely high boiling points are taken up by the propane solution in the treating process, and that thus a better separation of the aromatic and asphaltic from the paraffinic constituents is obtained by the solution-precipitation method.

In the removal of asphalt, wax, resins, etc., from reduced crudes or from distillates, the relative paraffinicity of the fraction treated determines the proportions of propane required for optimum results. Because of the low solvent effect of a high percentage of paraffinic constituents in the raw oil on asphaltic and other undesired materials a highly paraffinic stock such as a Pennsylvania residuum or neutral will require a lower ratio of propane to oil than will a Gulf Coastal or Western stock. The latter type of stock may require 12-15 parts of propane for each part of oil, whereas the paraffin-base stocks may employ only 8 or 10 to 1 ratios. Axiomatically, the degree of asphalt and/or wax removal desired is varied by the comparative amounts of propane used, as well as by the temperatures employed.

Propane shows increasing solvent effect on aromatic and asphaltic bodies as temperature is reduced, although the rate of solvent power loss with temperature reduction is low. At 80-100°F. appreciable amounts of asphalt, resins, and wax are held in solution. At minus 40-50°F. these products are precipitated almost quantitatively, yielding a propane solution nearly free of them. These low temperatures can be obtained by releasing the pressure on the solution to atmospheric gradually, permitting formation of optimum size wax crystals and the coagulation of asphaltic and resinous products.

Another interesting application of propane to lubricants is the use of propane solutions in conjunction with extractive solvents such as phenol, cresol, and others. Addition of propane to the mixture increases the "paraffinicity" of the raffinate phase. The purpose of the extraction solvent is to dissolve the more aromatic or less paraffinic components, rejecting the paraffinic portion as raffinate. Addition of propane, which dissolves selectively this paraffinic phase, increases the properties of the two phases in their respective directions, making the extract phase less soluble in the propane-dissolved raffinate or paraffinic phase, and vice versa, which results in a more exact separation. This has been taken advantage of in at least one commercial extraction process, as will be discussed in a later article.

Commercial Processes Using Propane, Etc.

One of the outstanding advantages of solvent dewaxing-deresining of a paraffinic stock such as a Pennsylvania residuum is that by removing the highest viscosity components, the resins especially, from this heavy residuum, the proportion of high to low viscosities in the crude, that is, the proportions of neutral oils to bright stocks may be changed, to utilize more of the heavy product. In recent years the increasing use of lower viscosity motor oils has placed a severe handicap on the refiners of premium-priced crudes high in lubricating oil fractions. Figures show that in the early 1930's the heavier motor oils then produced required only 45 percent neutrals to reduce the bright stock viscosities to meet market demands. In 1937, 65 percent of neutrals and 35 percent of bright stock were required to meet the lower viscosity requirements. (*National Petroleum News*, Oct. 19, 1938, p. R-504). This reduced the amount of bright stock that could be utilized by more than half, in 1937; our present consumption is probably about the same, or possibly it may require even smaller amounts of bright stock. The ratio of bright stock to neutral produced from Bradford crude is approximately 2.5 to 1, a total yield of about 23 percent. By reducing the viscosity of the bright stock, with small treating losses by propane deresining, more of the stock may be included in present-day motor oils, which is the principal outlet for Pennsylvania crude products. The stock is dewaxed with

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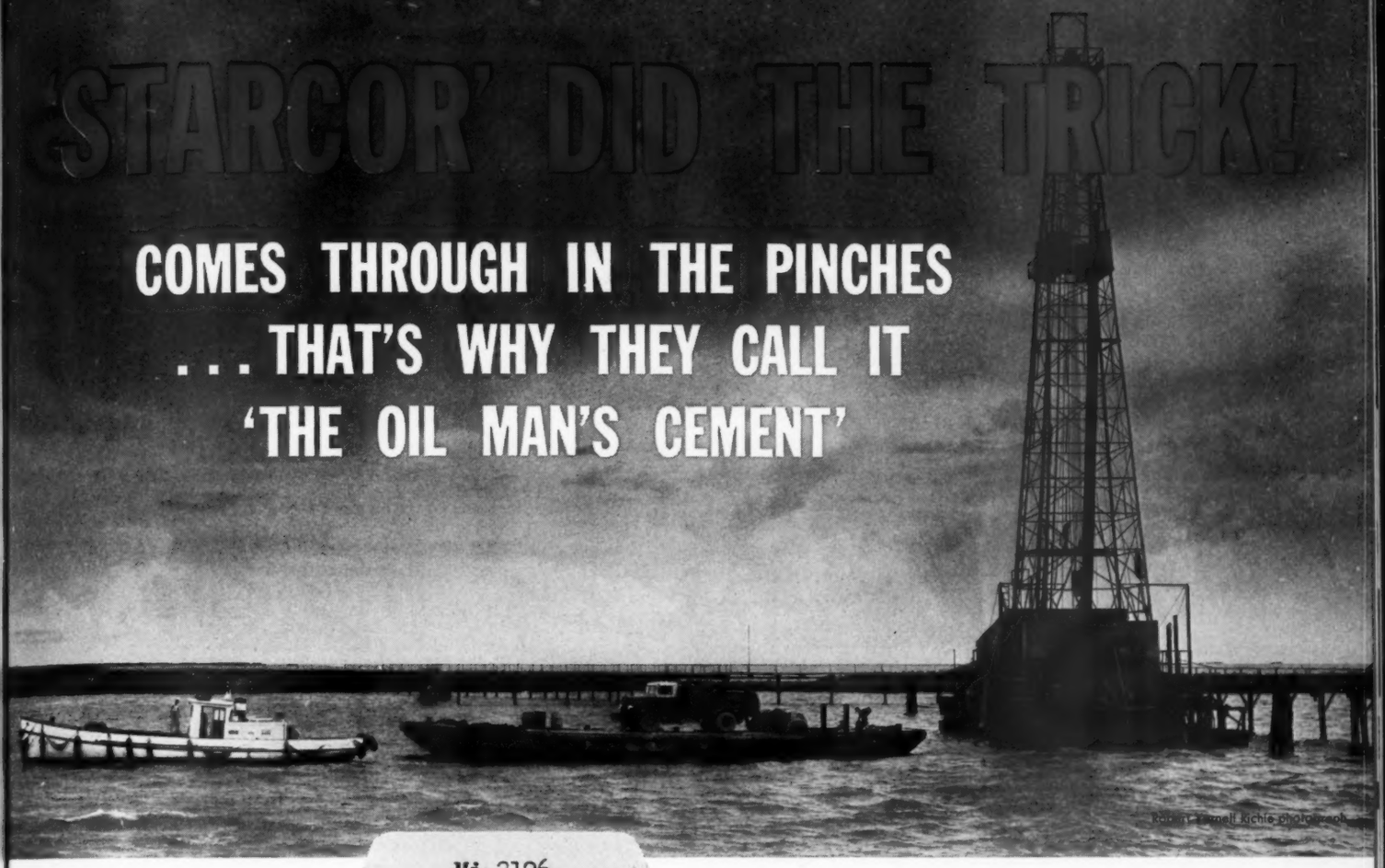

Mi-2196

FIELD: Lake Pelto, Louisiana
TYPE OF JOB: Casing; 7" O.D., 9-5/8" hole
DEPTH OF WELL: 5,500 feet
MAX. TEMP.: 150° F.
SLURRY WEIGHT: 16 lbs. per gal.
CEMENT USED: 'Starcor' - 400 sacks
MIXING TIME: 18 minutes
PUMPING-DOWN TIME: 27 minutes
MAX. PUMP. PRESSURE: 1800 lbs.
REMARKS: Mud weight, 10 lbs. per gallon; circulation broke at 900 lbs; well was circulated 1 hr. 20 min. prior to cementing... Another successful 'Starcor' job under unusual and difficult conditions.

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2-4 parts of propane using self-refrigeration to minus 40-50°F. The wax is removed in a rotary continuous drum filter, and more propane is added until the propane-oil ratio is, say, 10 to 1. The dewaxed cylinder stock has lost 13-14 percent by volume as removed wax.

The diluted propane solution precipitates 12.5 percent of resins under one procedure, leaving 74 percent of deresined oil ready for the clay filters to decolorize as desired. Incidentally the deresining step simplifies the decolorizing step and reduces its cost considerably. The resins so produced are treated with a 3 or 4 to 1 ratio of an extraction solvent such as phenol with the injection of 9-10 percent water. This yields 3 percent extract and 9.5 percent of raffinate that can then be combined with the deresined stock that has been treated with 80 percent or more of the same extraction solvent along with water injection of 11 percent. This combination of treatments resulted in a yield of more than 80 percent of the original cylinder stock with the viscosity lowered by about 25 percent. Such stocks can be so treated with propane as to extract or precipitate 30 to 50 percent of the charge as "resins," which can then be extracted with selective solvents to produce a wide variety of product properties to suit any set of requirements.

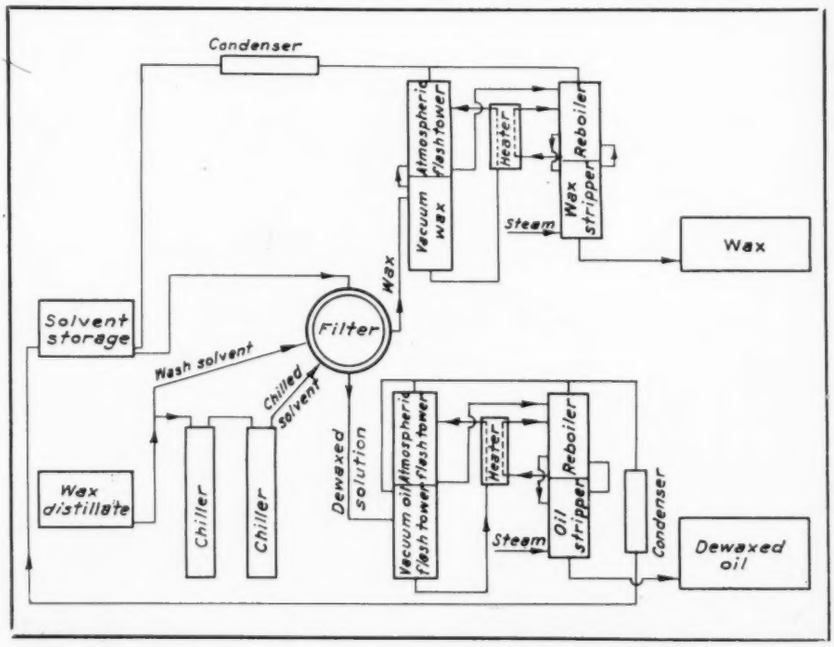
Some details of a continuous system for removal of asphalts, resins, and wax from a lubricating oil distillate may be shown, as those of the Sun-Alco process. This process removes resins, asphalt, and wax in one continuous operation, the asphaltic material serving as a filter-aid according to the claims of those who developed the process. The raw oil to be dewaxed is refrigerated by outside means such as ammonia expansion before adding propane. The propane is self-refrigerated by evaporation of a part of the liquid, and this cold solvent is added to the oil when the latter has already been cooled to within 20-30 degrees of the desired filtering temperature. It is claimed that by this method large, easily filterable crystals of wax are formed at a much more rapid rate than is possible when cooling the mixture of propane and oil after they have been mixed, by evaporation of propane. Rapid chilling usually means formation of a large number of small crystals that do not filter well; large crystal formation is the result of more leisurely cooling, forming an initial "crop" of crystals and then adding to these crystals to increase their size by continuing the slow cooling rate. Any method that will increase the permissible rate of cooling and retain the large crystal formation proves a decided advantage both in costs and in finished oil quality. The more rapid the filter rate the more complete the separation of oil and wax that is obtained and the lower the pour point of the oil, for any given filtering temperature.

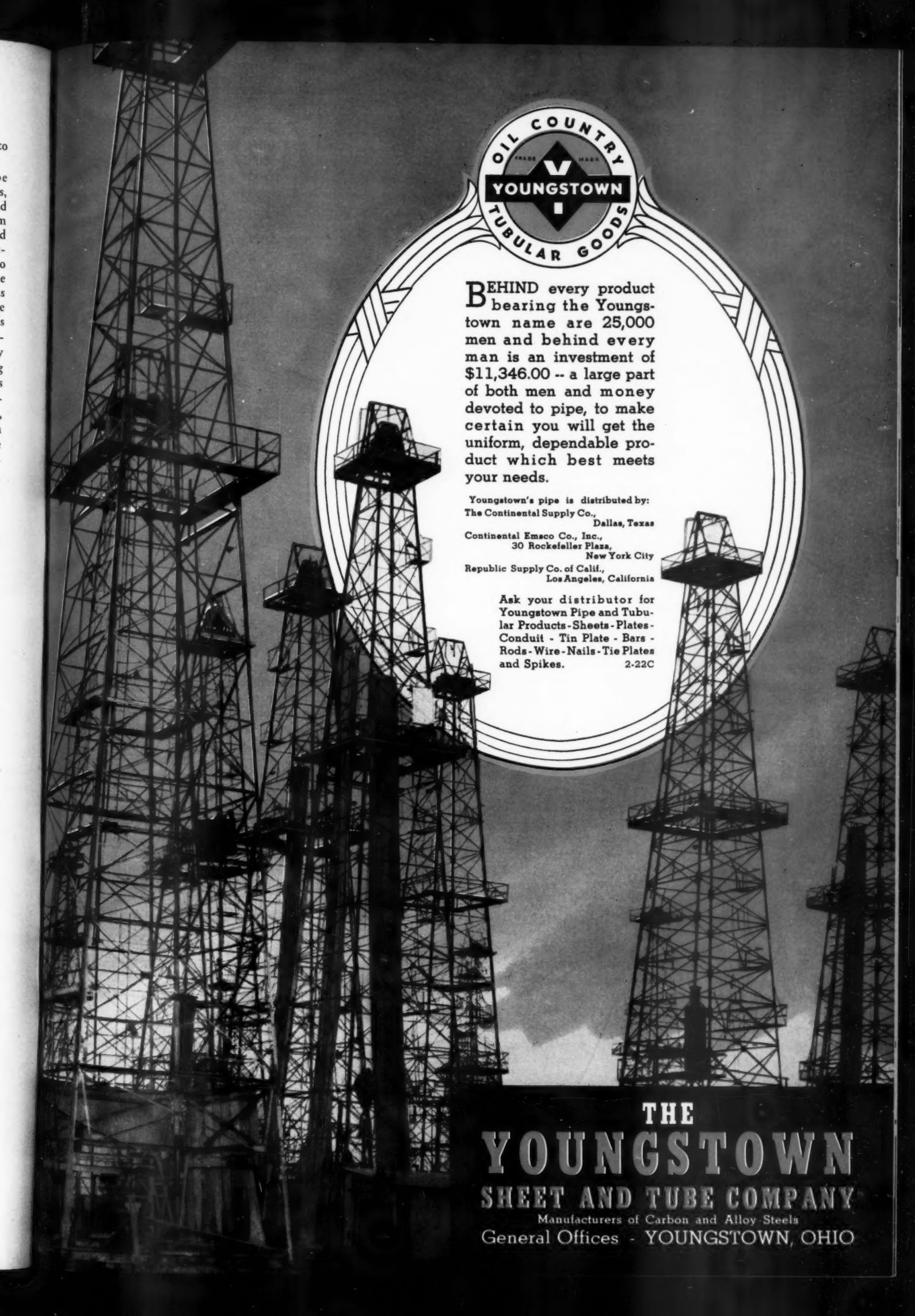
As an example of the major details of operation of this process, the crude oil, such as a Mid-Continent lubricating oil crude, is topped to any desired viscosity, blended with equal parts of propane under sufficient pressure to maintain the propane in a liquid state, and this blend or solution is pumped through a conventional double-pipe chiller, and cooled to minus 25°F. Four parts of propane are cooled by self-refrigeration to minus 45°F. and added to the chilled oil-propane mixture. This diluted solution precipitates the asphalt, resins, and wax, and is filtered, the asphalt acting as a filter-aid to "loosen" the wax bed on the filter, improving the filtration rate. The filter used may be any one of the continuous, rotary-drum machines such as the Birmingham type. The mixture of wax and asphaltic materials may be separated by distillation, taking the wax overhead by fire, steam and vacuum, or by selective solution and precipitation from propane or other solvent. This dewaxed-deasphalted residuum may be redistilled to such fractions as may be desired, it being claimed that redistillation does no damage to the products.

Treatment of Pennsylvania-type stocks is recommended in two steps, one on an overhead wax distillate and a parallel one on the short residuum steam-refined bottoms. The overhead distillate should have about 200 seconds Saybolt viscosity at 100°F. Ten to twenty percent propane is added to the distillate that is chilled to, say, minus 25° or minus 30°F., in double-pipe chillers, after which cold propane is added to give a 4:1 propane-oil solution. This solution is filtered in rotary continuous filters, exact control being necessary in this step as in the others to have a solution of the correct consistency with properly crystallized wax, fed at the exactly correct rate to give a "cake" of the desired thickness on the filter. Extensive heat exchange is employed in the chilling and filtering process to reduce chilling costs to a minimum.

Treating heavy residua with propane may require a greater variation in proportions of solvent and oil, depending on the viscosity, wax content, and asphalt or resin content of the oil. The viscosity is reduced by propane addition, indirect chilling is employed as with the overhead wax distillate, additional propane is used to obtain the final temperature reduction to minus 40-45°F., and the mass filtered in the same type equipment. The waxy filter residue may be redistilled to recover the waxes of the desired melting

Fig. 3. Flowchart of methyl-propyl, methyl-butyl ketone dewaxing process

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points. Much of the coloring matter in the raw oil is found in the heavy residue from this distillation, and the decolorizing costs for both the wax and the dewaxed oil are reduced by as much as 50 percent, claims state.

The filters employed to remove waxes and asphaltic matter from these diluted oils are a signally important development and on them depends much of the success of this type of operation. The chilled solution is led into a large horizontal drum fitted in its lower half as a container for the solution. This drum is hollow, over the cylindrical frame of which a heavy canvas filter pad is supported by heavy mesh or perforated screen. The interior of this drum is divided segmentally so that liquid products passing through the filter in different segments of the drum's rotation may be withdrawn to different rundown tanks. The lower third or two-fifths of the drum is submerged in the chilled solution, and suction equal to a few inches of water pressure is placed on the segments while they pass through this solution. As any given segment of the drum filter emerges from the solution the oil and propane solution is drawn from the waxy material caught on the pad into the drum's interior and flows to a rundown tank. As the given segment nears the top of the filter in its rotation, cold propane jets against the entire length of the filter, washing the last traces of oil from the wax layer, this wash propane being drawn from inside the drum to another rundown tank. A sharp scraper "knife" is adjusted to barely clear the filter pad at a point just before the pad re-enters the solution again; this knife scrapes away the wax continuously, leaving only a very thin layer of wax on the surface of the pad, which continues its rounds to collect more wax. The wax is conveyed from the filter and is melted and handled as a liquid thereafter. To avoid danger of explosions from the propane vapors present, a "blanket" of inert vapors such as flue gas is maintained on the filter jacket, giving a slight pressure so that inflammable vapors are not permitted to escape into the filter room.

Much of the sulphuric acid treating formerly employed to refine mixed-base lubricating oil fractions has been superseded by propane treatment. The two processes may be combined with advantage, according to Bahlke and his collaborators *(Proc., Second World Congress*, 1937). In deasphalting with refinery propane containing some butane, the temperature used must be higher, it is found, than when using pure propane. Also, the color of the deasphalted oil is lighter as the proportions of propane are increased or as the temperature is increased. Consequently a typical operation is: a Mid-Continent residuum of 400 viscosity at 210°F. is treated with three volumes of natural gas propane at 110°F., the higher temperature facilitating the deasphalting because the differential solubility of the asphalt at higher temperatures gives a lighter color product and faster asphalt settling. Pressure of 390-400 lb. is maintained on the asphalt settler, and liquid level controls permit introduction of oil to the settler and continuous withdrawal of deasphalted oil from the end opposite that at which the oil is introduced. Asphalt is also withdrawn continuously from the bottom of the settler, is pumped to the stripper column where pressure is reduced from 200 lb. to 25 lb. and hot gas oil is sprayed in to drive off the propane and flux the asphalt. This asphalt before fluxing has a melting point of about 150°F.

The deasphalted oil-propane solution is passed through an orifice mixer where it meets once-used acid sludge from the first treating stage, and is pumped to a separator from which the half-treated oil is sent to the first stage treater. The acid sludge is denuded of propane and sent to the plant recovery unit.

The sour oil-propane solution is next treated with 93 percent acid to obtain the desired color and clarification of the stock, this sludge passing to the second stage. The oil is neutralized with dilute (3 percent) caustic solution, washed, and the propane removed by exhaust steam. This method yields 20 gal. of asphalt and 21 gal. of acid sludge per 100 gal. of raw residuum as compared with about 120 gal. of total by-products under the older system, which included more than 100 gal. of acid sludge.

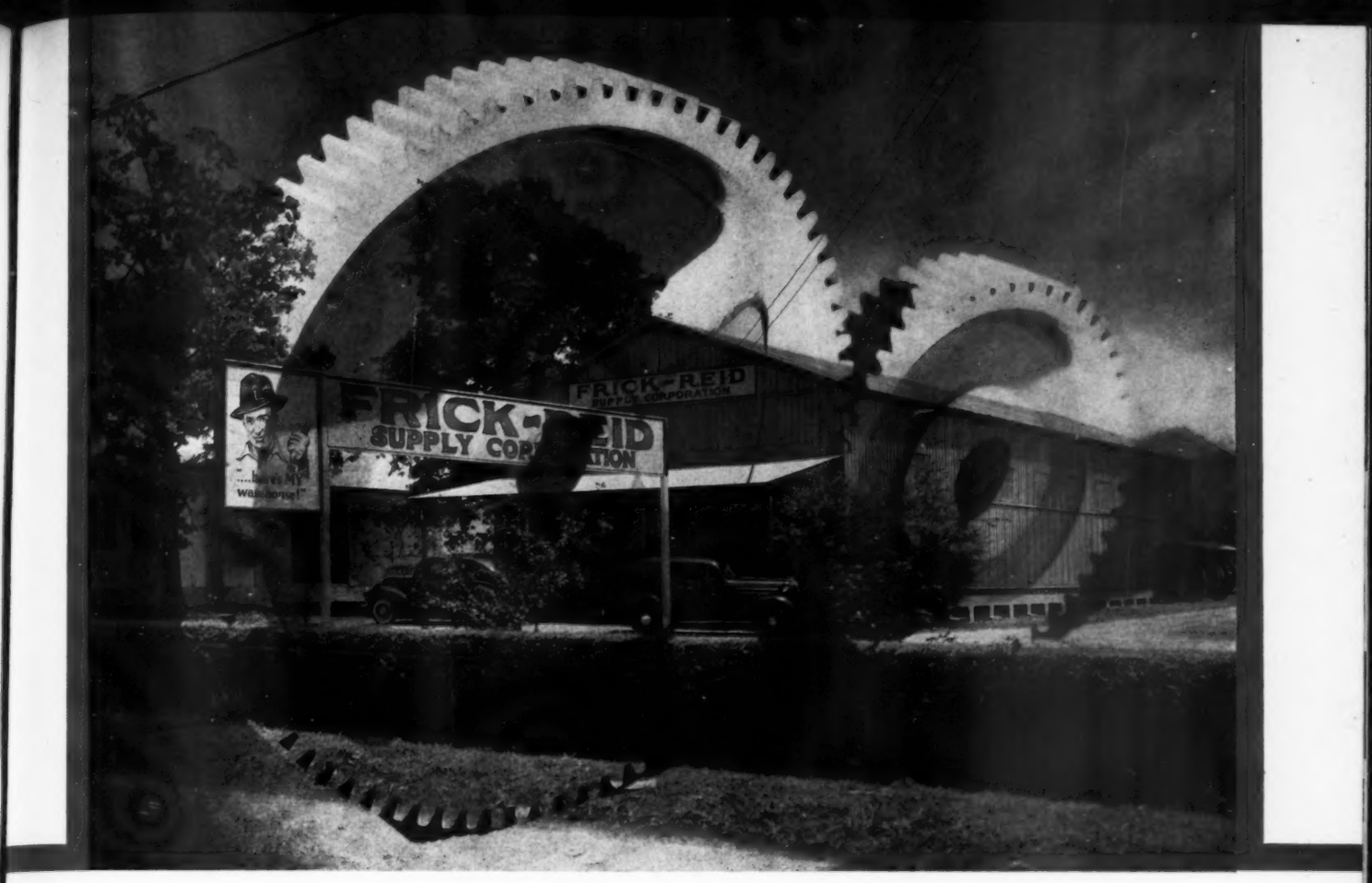
The methods here described for propane treating are applicable qualitatively to the use of solvents such as methylethyl ketone. The boiling point of the mixed ketone is higher than for propane so that recovery temperatures, pressures, etc., employed are higher and lower, respectively, than for propane.

Another dewaxing system, using a mixture of methyl-n-propyl and methyl-n-butyl ketones without benzol, has recently been applied successfully to dewaxing both Mid-Continent and Pennsylvania lubricating distillates. Methyl-n-propyl ketone is the better dewaxing solvent of the two in that it shows lower solubility for wax and in water, has a lower vapor pressure and lower cost, a higher filter rate, and a lower pour point for the dewaxed oil for any given filtering temperature. It requires a higher recovery temperature than does the methyl-n-butyl ketone.

A mixture of these two ketones, in which the proportions are adjusted to give optimum results with any given stock, shows decided advantages. These solvents have been used on stocks varying from 150 Saybolt seconds at 100°F. to 200 seconds at 210°F. Solvent losses average about 0.1 percent. Solvent-oil ratios of 3½ to 1 or lower are used normally. The wash solvent, which reduces the oil in the filter cake to 6-8 percent, is retained separately after the washing operation and used to dilute the incoming charge, reducing solvent recovery capacities and costs.

Wax distillate is mixed with wash solvent from the filter, the solution enters the chillers where it is first shock-chilled, and then chilling is controlled to build large crystals and thus to speed-up the filter rate. The solution enters the filter at 12° to 25°F., depending on the pour point desired in the dewaxed oil. After filtration the oil-wax solution and the solvent containing crude wax are flashed in recovery towers at atmospheric and then at reduced pressures, the bottoms in each tower are stripped with steam, and solvent vapors are condensed and returned to storage for re-use. Some solvent remains in the condensed steam and is stripped from it to reduce losses, before the water is discharged from the system. The amount of ketone remaining in the oil may range from 0.001 percent to 0.003 percent, and that in the wax may be as high as 0.001 percent, usually less.

The ketones are reported to show somewhat different solubility characteristics for different fractions of oil, and are used principally to remove wax from paraffinic base crudes. Bloom of oils dewaxed with ketones is said to be somewhat better than that of oils dewaxed and deresined by the use of propane, but this problem has been overcome as a better understanding of the use of propane has been gained.



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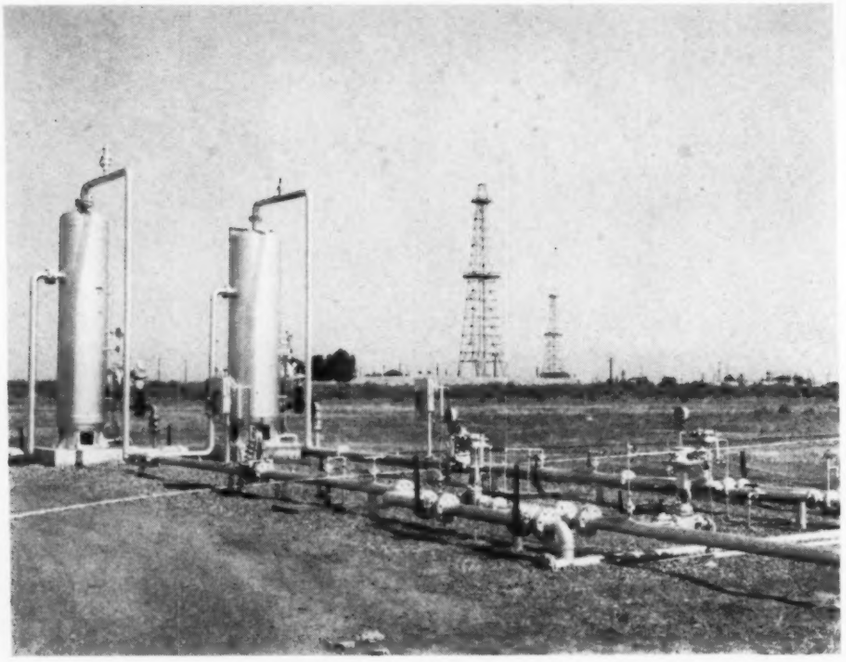


A typical two-stage separator hook-up in the Rio Bravo field, California

PETROLEUM ENGINEER EXCLUSIVE FEATURE

Gas and Oil Separation Practices in Deep Fields of California

Two methods employed: two-stage separation at the well and divided separation with high-stage separation at the well and low-stage separation at a central station

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

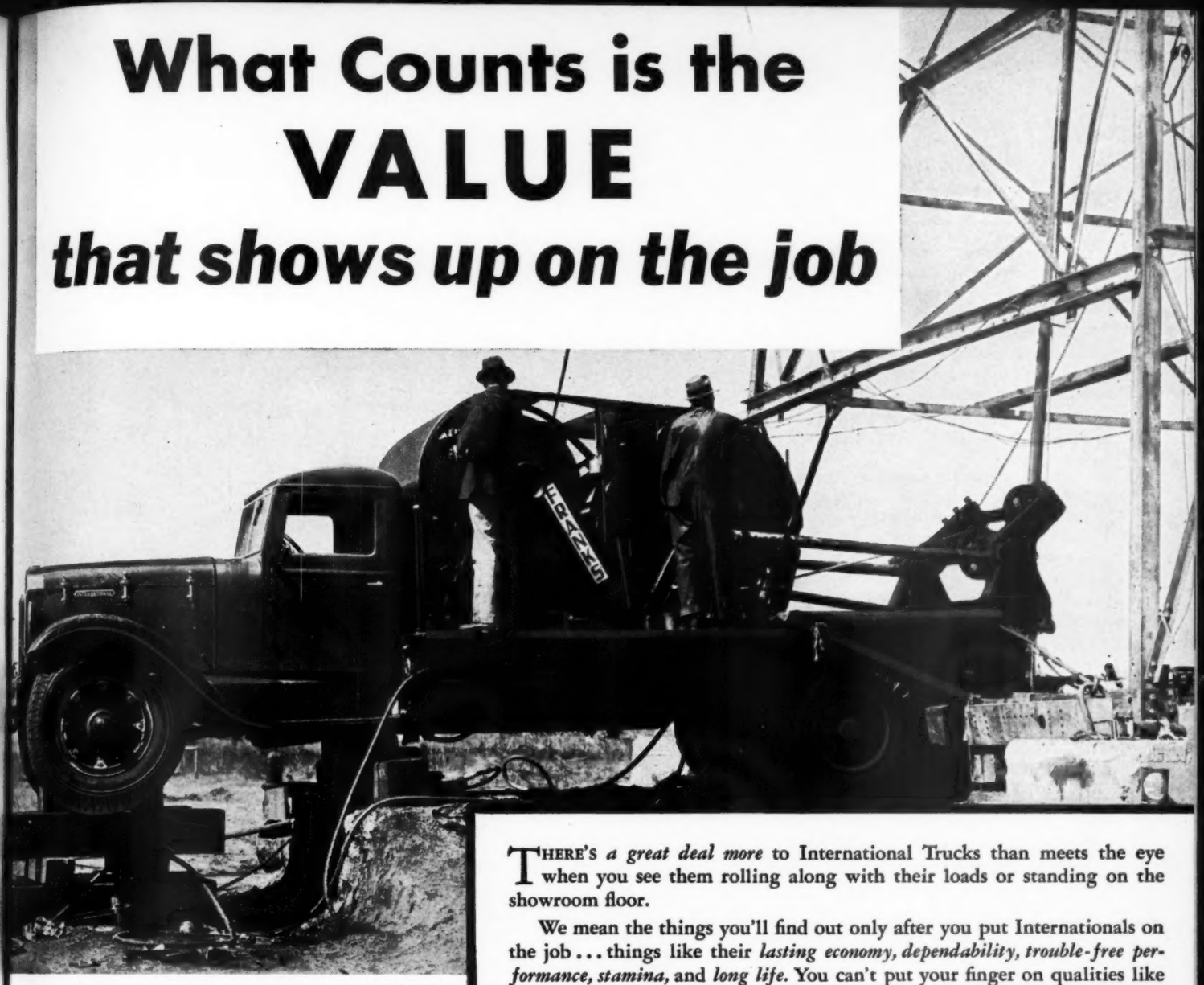
DUE to voluntary proration of production in California the capacity of separators handling gas and oil production from even the largest wells presents no problem at present except when a well is being cleaned-up. Except for a new trap in which tests have just been completed, the high-pressure separators have been capable of handling production at the rate of 1500 bbl. per day. The new type, due to an innovation in design, can handle 2500 bbl. per day. In the deep fields, however, pressures encountered, although not excessive for the depths, require the use of two-stage separation. In many installations two traps—one high-pressure and one low-pressure—are situated at the well but, as is the practice of one company operating in the Rio Bravo field, only a high-pressure separator is set-up at the well when a central station is used to handle production from several wells.

The gas-oil ratio of production from wells in deep fields of the San Joaquin Valley, where completions are at depths below 10,000 ft., is not excessive and the pinching-in of production has placed a back pressure on the wells that probably has increased ultimate yields from the fields. The maximum allowable per day per well is now 178 bbl. and this is obtained either by beaning the flow to that amount for constant production, by allowing a larger periodic flow, or, as in a few cases, by shutting-in some wells on a lease and taking the entire allowable over certain periods from specified wells. Conditions naturally govern the method used, and economic current production, longer flowing life, and higher ultimate yield are considered in determining the practice to be followed.

As the percentage of potential is small under any of the methods used, it appears that the gas-oil ratio of present production varies but little for different wells. In the Wasco field there is little gas produced with the oil and the gas-oil ratio of wells completed within the last few months is approximately 240 cu. ft. per bbl. of oil. At Greeley, production from the deep zone has a gas-oil ratio that does not average more than 800 cu. ft. per bbl. of oil, but at Rio Bravo the present production of recently completed wells has an average ratio of approximately 1200 cu. ft. per bbl.

Although not so deep as the Wasco field, Rio Bravo is somewhat analogous to the Greeley deep production and probably presents a representative picture of the methods used for handling oil and gas production from deep wells. The practices here are certainly modern and involve both two-stage separation at the well and divided separation with the high-stage separation at the well and low-stage separation at a central station. The average pressures maintained in the wells throughout the field range from 1500 lb. per sq. in. to 1700 lb. per sq. in. on the casing and from 1600 lb. per sq. in. to 1800 lb. per sq. in. on the tubing. Actual flow conditions of the two wells most recently completed—one by each of the two largest operators in the field—are shown in Table 1.

What Counts is the VALUE *that shows up on the job*



Here is the largest spudder ever mounted on a truck and driven by the truck engine—a double-drum combination drilling and clean-out machine on an International A-8 Truck. This portable outfit is owned by the S. E. Frogge Well Servicing Co., Oklahoma City, and shown here servicing a well in Oklahoma City. It drills to a depth of 7,000 feet, and cleans out to a depth of 10,000 feet. This International Truck engine is equipped with a natural gas carburetor, enabling it to use gas when it is set up on the job. The Frogge Company uses two more International A-8 Trucks for clean-out work.

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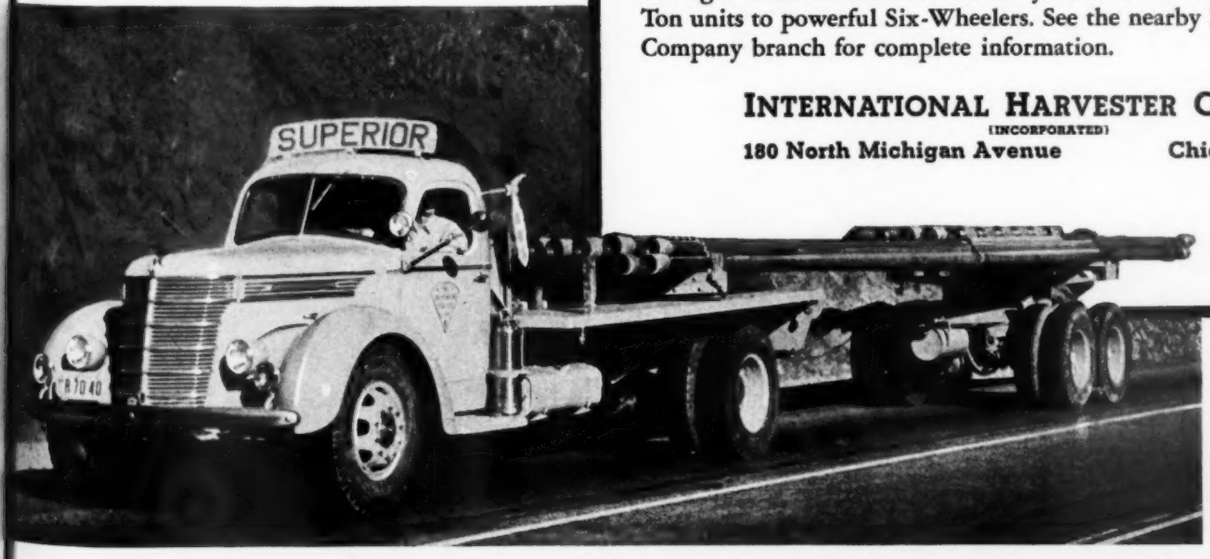
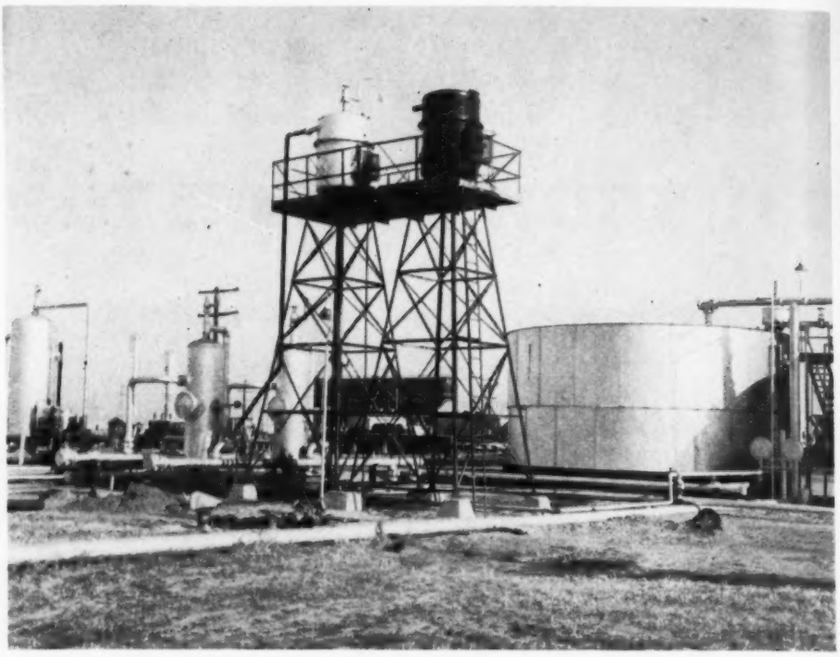


An International Heavy-Duty Truck hauling 40-foot lengths of 6-inch drill pipe on a 100-mile haul for the Superior Oil Co., Los Angeles.

NTERNATIONAL TRUCKS



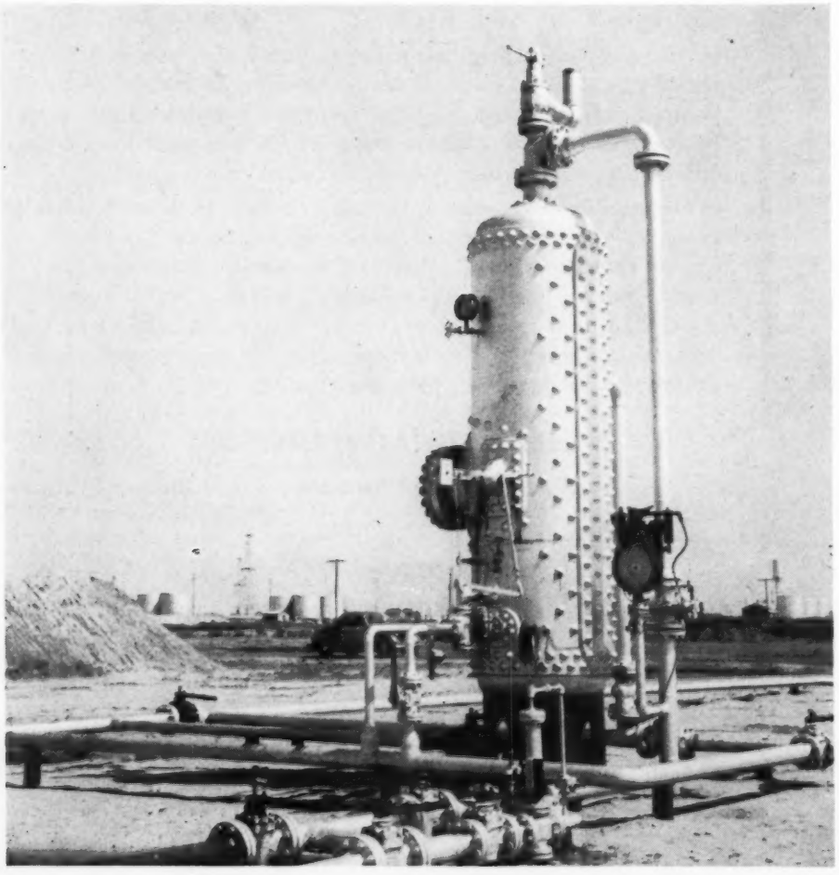
A part of the central flow station at Rio Bravo with low-pressure separators shown at the left

Typical separator hook-ups are shown in accompanying illustrations. Gas from well "A" is entirely removed by two separators placed at the well; gas from well "B" is partly removed by the one high-pressure separator at the well and the remainder by low-pressure separation at a central flow station. By using the two methods practically 100 percent of the gas is stripped from the oil.

Using average figures for the Rio Bravo field, production from the well enters the high-pressure separator on the left in which a pressure of 470 lb. per sq. in. is maintained. The gas taken off at this pressure goes directly to a natural gasoline plant situated on the west side of the field and is there put directly through the absorbers. The oil then passes to the low-pressure separator where the pressure is maintained at 35 lb. per sq. in. The gas taken off at this pressure goes through another line to the gasoline plant where its pressure is increased and, together with the high-pressure gas, is passed through the absorbers. Approximately 75 percent of the gas is removed in the high-pressure separator and 25 percent in the low-pressure separator.

TABLE I

	Well "A"	*Well "B"*
Oil in bbl. per day	1435	1410
Gas in M. cu. ft. per day	1800	1620
Size of choke	28/64 in.	22/64 in.
Tubing pressure	1625 lb. per sq. in.	1600 lb. per sq. in.
Casing pressure	1725 lb. per sq. in.	1825 lb. per sq. in.
Gravity, deg. A.P.I.	38.7	37.6
Cut, percent	0.1	0.7
Depth of well	11,483 ft.	11,470 ft.



This one high-pressure separator is set up at the well and from it the oil and remaining gas are piped to a central station where they pass through a low-pressure separator

The details of manifolding naturally vary to some extent with each company but in general complete flexibility in control of flow through and around the separators is provided. Either or both separators can be by-passed and all contingencies of flow met. Gas from each separator is measured by orifice meters and the recent custom has been to place the orifice flange on the vertical gas line leading downward from the top of the separator as can be seen in the photograph of the single trap. This eliminates the collection of condensate at and around the orifice and has been found to be a very satisfactory arrangement.

The pressure of 470 lb. per sq. in. is maintained constant on the high-pressure trap by means of a regulator. The pressure downstream from the regulator varies between 450 and 455 lb. per sq. in. Likewise, the pressure of 35 lb. per sq. in. is maintained on the

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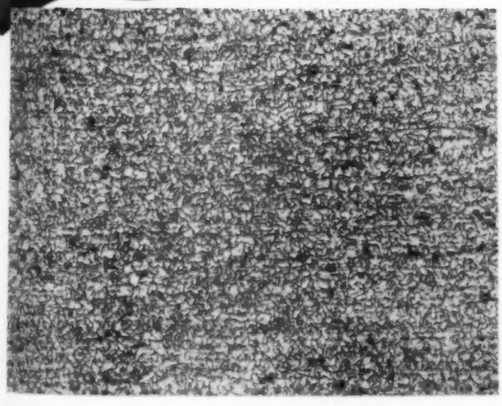
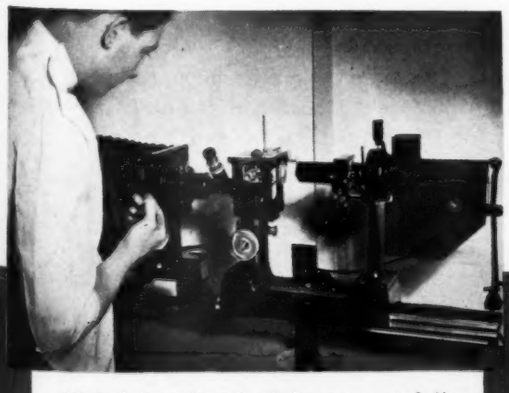


This photomicrograph shows the uniformly fine grain structure of D + B Reliance Sucker Rods after the Precipitation Strengthening treatment.



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low-pressure separator where the pressure downstream from the regulator varies to a greater extent because of compressor variations and influence of condensate in the lines. By keeping the pressure constant through the meters the charts are more easily read.

When only a high-pressure separator is placed at the well the manifold system is as shown in the illustration of the single trap. Only the one high-pressure gas line from the well to the gasoline plant has to be used, but an oil line from each well has to be laid to the central station, as would have to be done regardless of the system used to get oil to the storage tank. The high-pressure gas from the separator, as in the case of gas from the high-pressure separator described, goes directly into the absorbers upon reaching the gasoline plant.

The oil arriving at the central station from the well passes through a low-pressure separator where the remainder of the gas is removed. This gas is then boosted in pressure and enters the absorber with the high-pressure gas. At low production rates the high-pressure separator at the well takes off 80 percent of the gas volume and the low-pressure trap at the central station strips the other 20 percent.

The arrangement of separators and tanks at the central station, where the production from 32 wells on the one lease in Sec. 34-28S-25E will eventually be handled, is shown in Fig. 1. The drawing also shows the system employed for handling the oil from a group of eight wells. The central station at Rio Bravo is laid out so that there is one low-pressure separator and one oil meter for each eight wells on the section. This permits metering the oil from each well once every eight days or once every four days if 12-hour gauges are used. Although there are four low-pressure traps and meters for measuring the oil production, the oil from the remaining wells not being gauged passes through a fifth low-pressure separator. The one low-pressure separator is adequate to handle the low-pressure oil and gas from all wells not being metered and performs effectively, as the present production in California is so restricted.

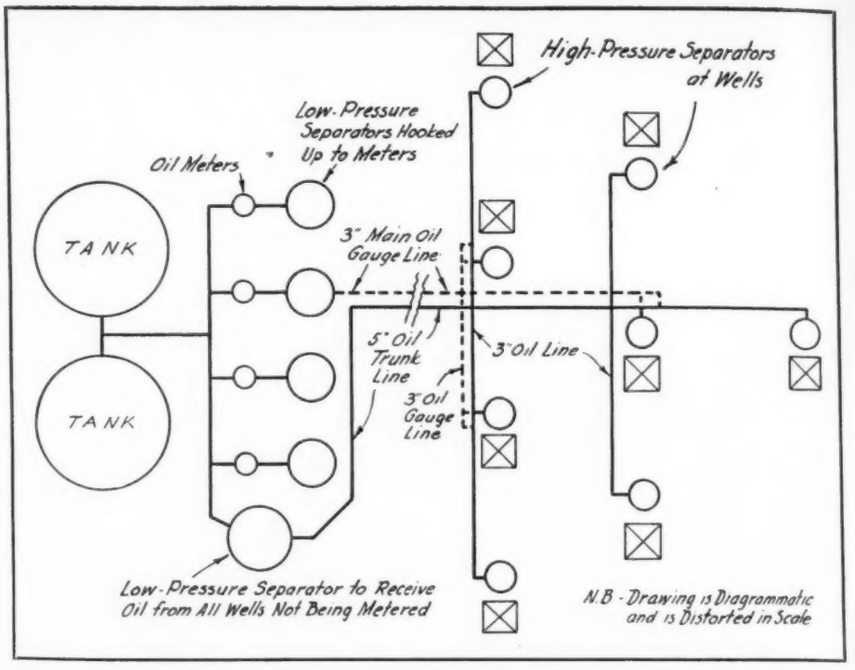
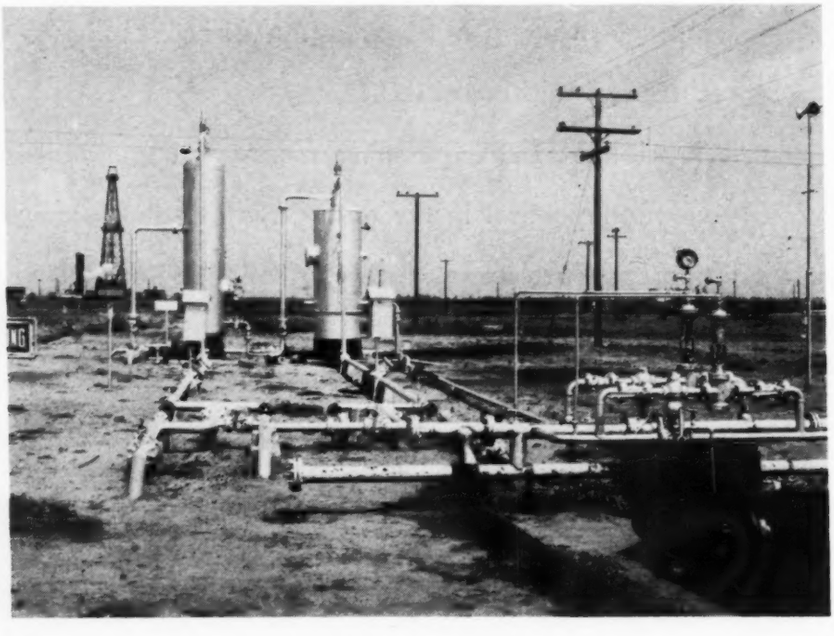

High-Pressure Separators at Wells
Low-Pressure Separators Hooked Up to Meters
Oil Meters
TANK
TANK
3" Main Oil Gauge Line
5" Oil Trunk Line
3" Oil Line
3" Oil Gauge Line
Low-Pressure Separator to Receive Oil from All Wells Not Being Metered
N.B - Drawing is Diagrammatic and is Distorted in Scale

Fig. 1. Low-pressure separators, oil meters, and tanks at a central station for handling oil from 32 wells. The method of handling one group of 8 wells is also shown. The low-pressure separator at bottom takes oil from all four 8-well groups but each of the 4 separators hooked-up to meters handles one well from one group at a time

High-pressure absorbers are used at the Rio Bravo gasoline plant and the low-pressure gas boosted to the necessary pressure because the residue is put directly into a fuel line for transportation and sale. The economy of this method is evident, as approximately 75 percent of the gas is removed at a pressure greater than 450 lb. per sq. in. and only the 25 percent taken off in the low-pressure separators has to be compressed.



A gas and oil separation hook-up in the Greeley field. The high-pressure separator at the left carries a pressure of 500 lb. per sq. in. and the low-pressure separator a pressure of 60 lb. per sq. in. The well pressures at this location are 1500 lb. per sq. in.. on the casing and 1400 lb. per sq. in. on the tubing

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Refinery Steam and Its Efficient Utilization

Part 2 (Concluded)

By R. G. LOVELL

Development Engineer, Hancock Oil Company of California

LITTLE imagination is required to reach the conclusion that if the supply of air can be stopped immediately, or before the liquid becomes heated from the incipient fire, then there is no more fire. It is of no particular importance how the air supply is stopped nor what material or agency is used.

On the other hand, if the fire has gone on for some time and the liquid is boiling violently the job becomes more complicated. The material used to blanket-off the air must have sufficient cohesion to withstand rupture by the boiling oil. This, steam cannot possibly do and, in fact, its use is likely to increase the fire by encouraging boiling just as it does when used in the distillation process. The answer then is clear. *Get the steam to the fire quickly or not at all.*

The other class of fire, issuing from a restricted leak, must be viewed somewhat differently. There is no fear of increasing the fire from accelerated evaporation because there is no considerable mass of oil. The task then is to close off the supply of air that is supporting combustion and to lower the temperature of the non-combustible material surrounding the fire to below the ignition temperature of the oil. If the size of the fire permits close approach, or if water fog is available to protect men with the steam hose from the heat, the steam can also be used to subdue the fire by actually blowing it out and then cooling the source so that flame will not recur. In the case of that most prolific source of refinery fires—a heater tube rupture—steam is very effective if used in conjunction with water streams on the outside walls of the structure. Assuming that the charging pump has been stopped and the supply of fuel to burners shut off, the only things to be done are to hold down the volume of the fire with the steam smother and minimize damage to the heater structure by keeping all parts cool with liberal quantities of water.

The Three Functions of Steam Correlated

The accompanying diagram, Fig. 1, will be used as a basis for correlating the use of steam for power, as a distillation control, and for combating fires as discussed above.

Assume a boiler pressure of 250 lb. per sq. in. gauge or 265 lb. absolute.

The photograph and biography of R. G. Lovell, writer of this article, can be found on page 63 of the June issue of *The Petroleum Engineer*, in connection with Part 1.

This is a perfectly reasonable figure and will serve to point out the advantages of the proposed plan. The pertinent figures from the steam tables at this pressure are listed in Table 2.

The steam will first be used in turbines driving centrifugal pumps for charging the heater, for pumping reflux, and for pumping hot bottoms through the heat exchangers to storage. Centrifugal pumps have been selected for the purposes of the problem, not with the idea that they would be more efficient in the use of steam than the conventional, direct-acting, reciprocating pump, but for other reasons. The principal reason is that the centrifugal pump is logically a high-speed device, which lends itself best to steam turbine drive. This type of drive unit, in turn, offers the best all-around speed control characteristics. Another important reason is that the necessity of supplying an unusual demand for distillation or fire steam can be met so easily by automatic bleeder valves that can open and supply this demand directly from an intermediate stage of the turbines. Some will argue that this should be done directly from the boiler. There is no valid reason why this means should not be provided, but only for emergency use, for obvious reasons. A check valve, however, placed as shown on the diagram would prevent high-pressure steam from entering the feedwater heater-accumulator.

Proper Point of Entry For Main Distillation Steam

It has already been stressed that steam for distillation functions entirely through the operation of certain well-understood laws of physical chemistry, and not by virtue of its temperature or pressure. The effect of steam upon the degree of vaporization of the crude oil and consequent end boiling points of the overhead stocks is in direct relation to the number of pounds—weight, not pressure—that is used per unit of weight of the crude oil to be vaporized. This should make it entirely clear that the only advantage in the use of superheated steam for this purpose lies in the fact that if the steam is at the same temperature as the crude oil then no heat need be taken from the oil to equalize the temperatures of the steam and the crude. One might then argue—and with some reason—that water could be used and thereby avoid the use of boiler capacity. To analyze this point thoroughly requires a study of the properties of both water and steam at the pressures proposed in the diagram. Note that the pressure on the heater-accumulator is 25 lb. per sq. in. gauge, which is determined by adding a normal pressure of 15 lb. per sq. in. gauge on the tower, to a pressure of 10 lb. per sq. in. required to equalize the pressure drop in the crude oil transfer line between the point of entry of the steam and the tower. Note: In the diagram, the steam for crude vaporization is shown as entering the transfer line some distance ahead of the tower instead of at the side of the vaporizer section of the tower. This is general practice and the writer has found that the method has certain distinct advantages.

The time during which the steam is in direct contact with the crude between the point of entry and the point of discharge into the tower will have given opportunity for a more complete and intimate mixture of the two materials and, in fact, will have induced some degree of vaporization in the line. This prevaporizing will increase the velocity because of having increased the volume. Actually prevaporizing has been found to have lowered the duty upon and, consequently, increased the efficiency of the lower trays. Side connections for steam

(Continued on Page 51)

(Continued from Page 48)

are obviously necessary for close control of boiling range of side cuts.

Relative Advantages of Water and Steam

The only possible advantage of steam over water—assuming that entry is made as shown—lies in the fact that the latent heat of vaporization of the water into steam would, if water were to be used, need to come from the hot crude. To supply this enormously greater amount of heat to the crude in the tube heater could require such a high temperature that decomposition—cracking—would take place. A study of Table 3 will serve to bring out this point and further will indicate that the advantage of high-pressure steam, from the same angle, is slight.

How the Accumulator Functions as a Boiler Feed Heater

It will be obvious that conditions will differ in every refinery and that these varying conditions will govern the balance between available exhaust steam and the distillation requirements. The latter can generally be satisfied by allowing 0.5 lb. per hr. of steam per bbl. per day of total overhead stocks. This can be translated into terms of boiler horsepower required for distillation steam in this manner:

Assuming 2500 bbl. per day of total overhead stocks, we have $0.5 \times 2500 = 1250$ lb. of steam per hr. or, approximately 40 boiler hp.

Steam turbines driving centrifugal pumps and exhausting against a back pressure of 25 lb. per sq. in. gauge are likely to have a water rate of from 65 to 85 lb. of steam per mechanical hp-hr. The exhaust will, of course, also be required to act as a heating medium for the boiler feedwater make-up and, obviously, this must be provided for in calculating the amount of exhaust steam required. The amount of exhaust steam so required will depend upon the temperature of the make-up water. In general, it would, of course, be advisable to return as much exhaust steam from other steam-powered units as possible or practicable. The amount of exhaust steam from these sources reaching the heater in the form of steam will govern largely the amount of heat used for raising the temperature of the make-up water. This involves, of course, the use of back pressure on the units exhausting directly into the heater. A simple calculation will show that this condition is not so unfavorable as it looks. It must also be remembered that such exhaust, if from turbines, is free from lubricating oil, which makes for more satisfactory boiler operation. If a part of the make-up water comes from a hot well into which the exhaust steam from the reciprocating pumps is discharged, the lubricating oil-water emulsion that has not been siphoned out in the hot well can be handled in the heater by use of surface blow-down.

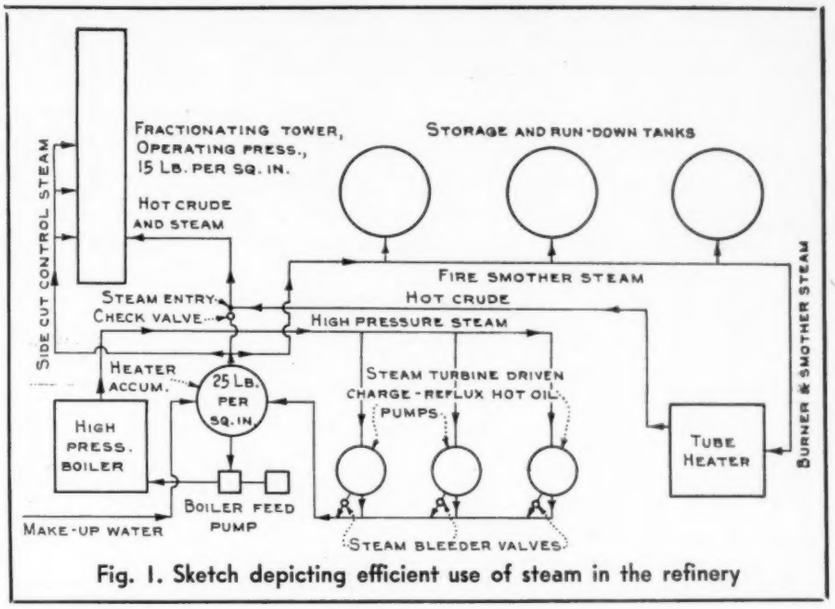
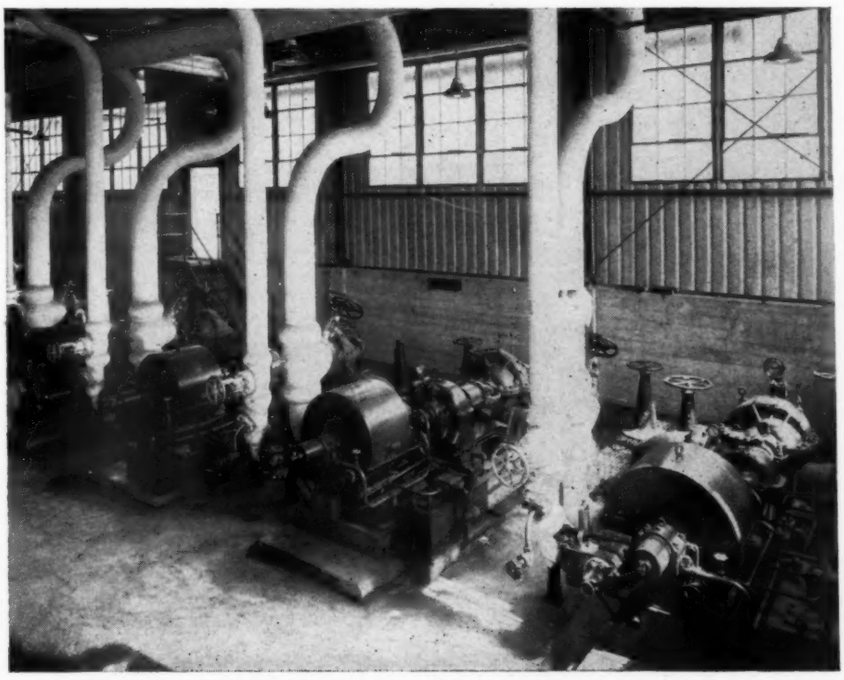


Fig. 1. Sketch depicting efficient use of steam in the refinery

Type of Heater

In many Mid-Continent, Pacific Coast, and Gulf Coast refineries, fuel cost is of only minor importance and to provide a means of maintaining pressure and temperature in the heater by light firing is clearly worth considering. This is not difficult to accomplish if a small vertical boiler is used as a heater-accumulator. This type of boiler lends itself readily to service of this kind because it is light-weight and can, therefore, be easily mounted on a superstructure a few feet above the boiler feed pump. The necessity for this elevation will be presently brought out. Because of certain inherent features in its design no particular heed need be given to carrying full water



Three 330-hp. and one 135-hp. steam turbines driving pumps. Turbines operate on 450-lb., 100° superheat steam and exhaust at 150 lb. and 50° superheat.

level; in fact, if the water level is purposely maintained relatively low the steam will be entirely dry and superheated to a slight degree. If such a boiler is used as a heater-accumulator, its steam is also available for atomizing fuel oil at the burners and for driving the fuel-oil pump. The latter duty is practical only if the circulating, low-pressure system is used for the fuel oil.

Is a Feedwater Heater Justified?

To determine whether a feedwater heater is justified, it is necessary to obtain a clear view of the advantage of the proposed scheme, in reducing load upon the high-pressure boilers and in fuel savings.

As the turbines driving the pumps are exhausting at a back pressure considerably higher than atmospheric pressure, their steam consumption will, necessarily, be greater than if the back pressure were normal. We will, however, have saved some part of the latent heat of vaporization, which would otherwise have been lost, because the exhaust steam at atmospheric pressure must necessarily be permitted to resume the water state before it can be pumped to the boiler.

The conditions under which an actual plant similar to the one outlined has been used have always been so varied that no accurate calculation of the actual net saving has been practical. In any event, the reader may be assured that the saving in boiler duty alone will approximate 20 percent.

Will the Boiler Feed Pump Handle Water at This Temperature?

Most of us have been taught that the maximum temperature at which water could be handled by a pump was about 160°F. This rule, like many others, is based upon the assumption that the average man can not, or will not, make use of the extreme flexibility of the rule by careful and informed consideration of all angles of a case in point.

Water and steam can and do exist in a boiler, or other vessel, at the same time, with the water in the lower part and the steam overhead. So long as the pressure and temperature are kept constant no change in their relative volumes can occur. If the temperature is increased by addition of heat from an outside source and no provision made for escape of steam—representing the amount of added heat—then the respective volumes will remain the same, as the rise in temperature has been accompanied by an increase in pressure.

If a volume of steam equivalent to the amount of added heat is allowed to escape, the water volume decreases and the steam volume increases in the proportion of their specific volumes at the specified pressures. If water is withdrawn from the bottom of the vessel the tendency is for the pressure to drop, which permits additional water to evaporate into steam, and in so doing latent heat of vaporization is consumed that brings the contents of the vessel to a lower temperature, which is that of boiling water at the lower pressure. During this last process, if heat is added at the same rate and in the same amount as it is being withdrawn in the water, then no change whatever will take place in the original pressure-volume-temperature relationship.

Within the relations outlined lies the answer to the question of whether the boiler feed pump will handle water at the temperature (267° F.) equivalent to 25 lb. per sq. in. gauge pressure.

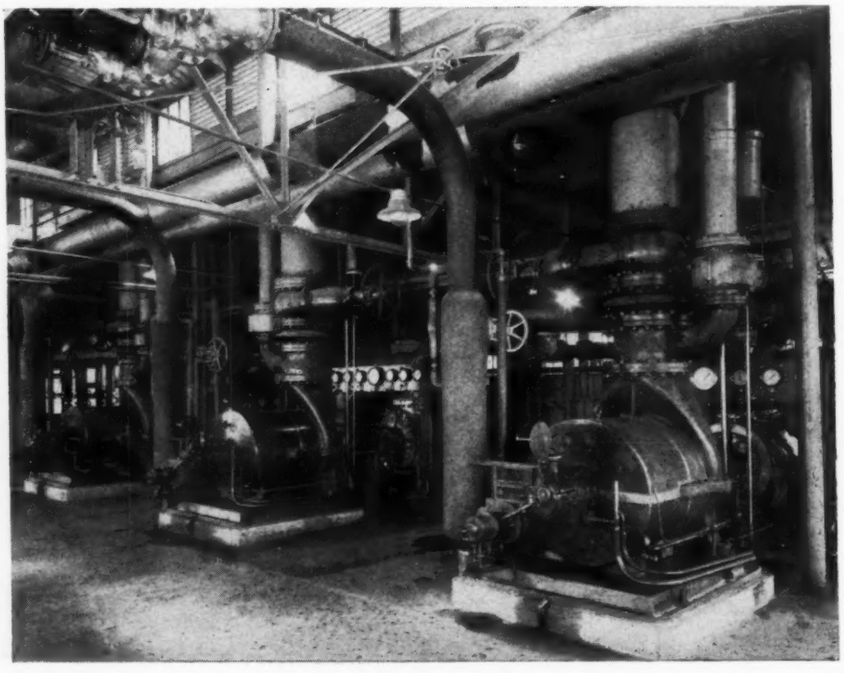
The answer is definitely yes, if such conditions of pump piston speed, inlet valve area, suction line area, and actual static head are provided as will insure that the 25 lb. per sq. in. will be maintained in the pump cylinder throughout the suction stroke. And this amounts to providing ample cross-sectional area of line, few turns, efficient insulation, and low piston speed so that unavoidable sources of pressure drop, such as practical inlet valve port areas, may be balanced by a minimum number of feet of static head of the heater over the pump. This is a very simple calculation and the writer has not yet observed a case in which the elevation was required to be in excess of 10 ft.

TABLE 2

Pressure, lb. per sq. in., absolute	Temperature, °F.	Heat of liquid, B.t.u.	Latent heat of evaporation, B.t.u.	Heat content of steam, B.t.u.
265	406	380	822	1202

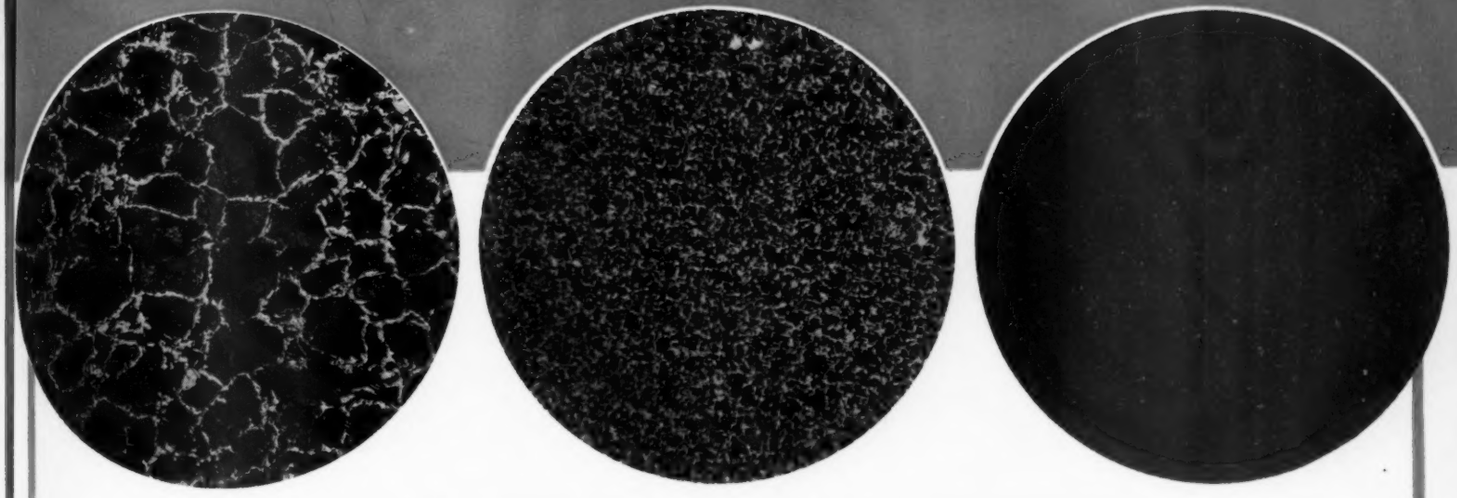
TABLE 3

	Pressure, lb. per sq. in. gauge	Temperature, °F.	Heat of liquid, B.t.u. per lb.	Total heat, B.t.u. per lb.	Heat from crude to equalize temperatures, B.t.u. per lb.
Water	25	212	180	180	1100
Water	25	100	68	68	1212
Steam	25	267	236	1169	111
Steam	250	406	380	1202	33



Condensing steam turbines driving hot-oil pumps. Exhaust steam from high-pressure turbines is supplied at 150 lb., 50° superheat.

"Oilwell" Triple Heat-Treatment Assures Maximum Endurance of Sucker Rods



Photomicrographs showing sucker-rod grain structure (ENLARGED 100 DIAMETERS)

1. **AS FORGED** — large grain structure usually indicates loss of strength. The upsetting operation produces undesirable strains in the metal.

2. **NORMALIZED**—to reduce grain size and to relieve forging strains. Steel possesses greater toughness.

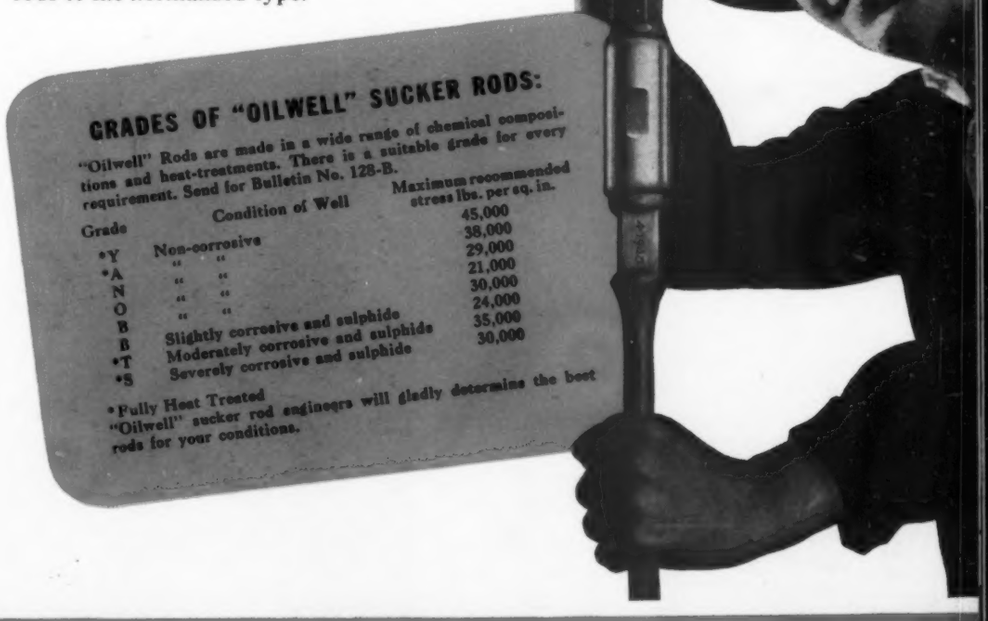
3. **TRIPLE HEAT-TREATED** — dense grain structure. Steel possesses its most desirable combination of strength, hardness, toughness and resistance to fatigue.

FULL HEAT-TREATMENT is the best-known method of increasing the endurance properties of sucker rods. With "Oilwell's" exclusive *triple heat-treating* process, the recommended maximum unit stresses for a given type of steel are substantially increased. This permits pumping deep wells and lifting heavy loads with a higher factor of safety. Rod failures are reduced and lifting costs are lowered.

"Oilwell" fully heat-treated sucker rods receive three separate heat treatments from end to end—normalizing to relieve forging strains; heating and quenching to obtain maximum strength, hardness and fine grain structure; drawing or tempering to impart toughness and resistance to fatigue.

If any one of these operations is omitted or applied only to the ends, the result is a weaker rod.

For sulphide and non-sulphide corrosive wells, "Oilwell" has developed special nickel-molybdenum steel sucker rods which have rendered excellent service under the most severe pumping conditions. Being *triple heat-treated*, they may be subjected with safety to higher stresses than corrosion-resistant rods of the normalized type.



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Grade	Condition of Well	Maximum recommended stress lbs. per sq. in.
*Y	Non-corrosive	45,000
*A	" "	38,000
N	" "	29,000
O	" "	21,000
B	" "	30,000
*B	Slightly corrosive and sulphide	24,000
*T	Moderately corrosive and sulphide	35,000
*S	Severely corrosive and sulphide	30,000

*Fully Heat Treated

"Oilwell" sucker rod engineers will gladly determine the best rods for your conditions.

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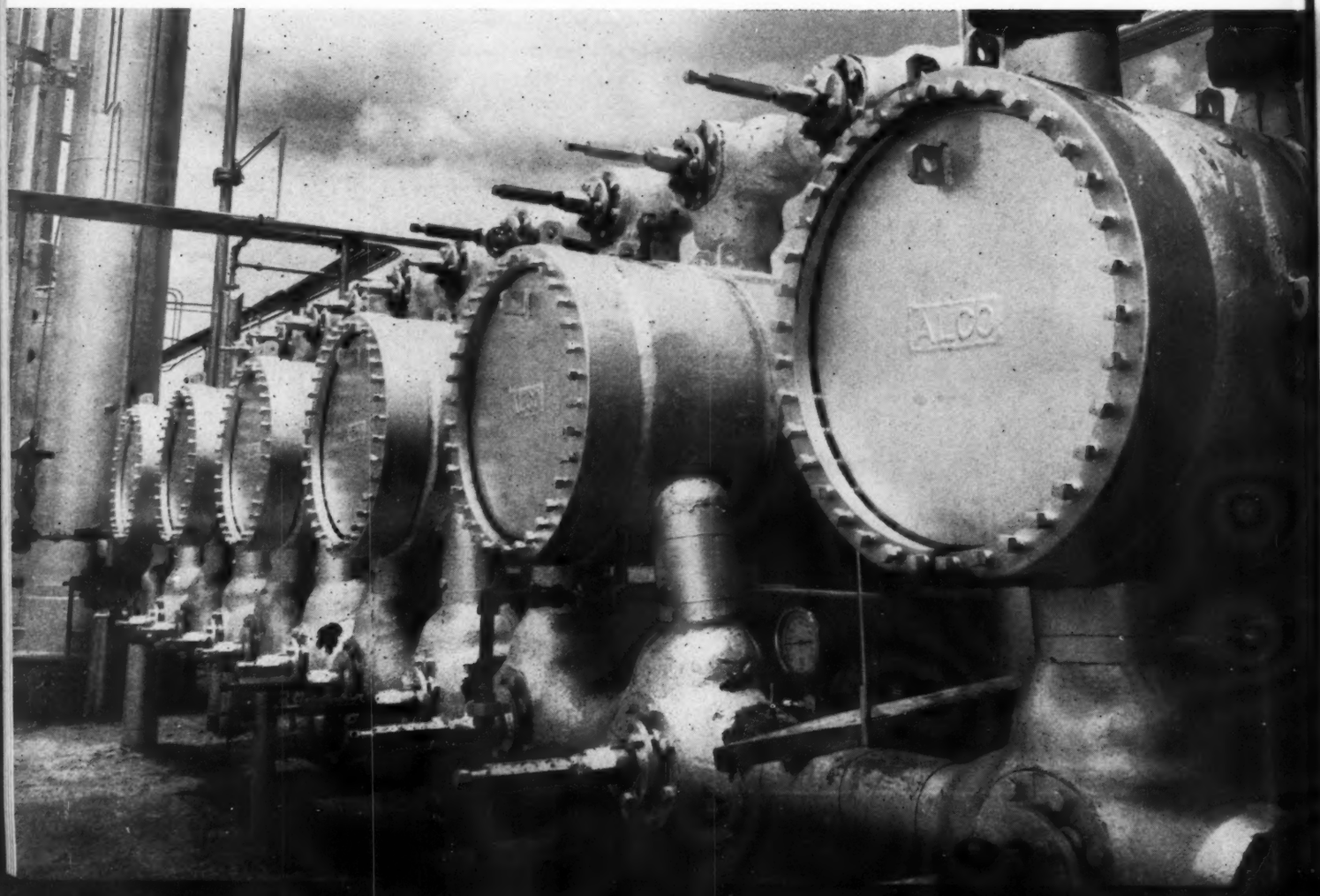
Tankage in lower background; steam lines overhead

(Photo by Meisel)

(Photo by Meisel)

Battery of heat transfer equipment



P 773.1

Distillation and stabilization units

(Photo by Meisel)

Recycling Plant Owner Selects High-Pressure Absorption

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

New installation in Long Lake field, Texas, operates at 1500-lb. processing pressure and returns gas at 2150 lb.

By FRANK H. LOVE
Managing Editor

ONE of the newer recyling plants is that of the Hunt Oil Company in the Long Lake field, Texas. The plant operates on the absorption principle, has a capacity of 50,000,000 cu. ft. of gas per day, and is capable of manufacturing 63,000 gal. of stabilized distillates—gasoline and kerosine.

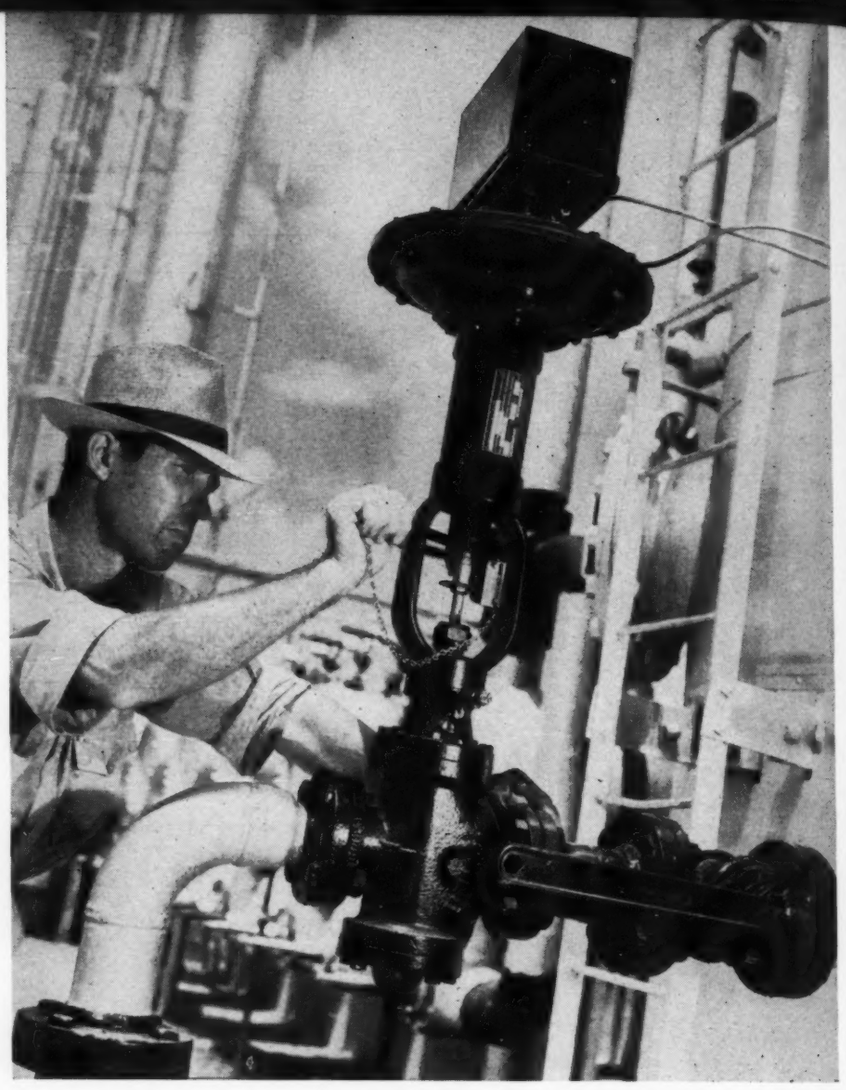
Operation is at high pressures, gas being received at 2000 lb. per sq. in. and reduced at the absorbers by a reducing valve to 1500 lb., the operating pressure of the plant.

The plant is modern in every detail. New-type equipment lends to efficient operation and the safety factor has been provided for by installation of automatic stations that instantly shut down the plant in event of anything going amiss with the equipment.

Each of the two 63-ft. absorbers is provided with meters to measure gas and mineral seal oil. After the distillate has become absorbed in the lean oil the dry gas is taken by the suction of the compressors at a pressure of 1500 lb. and compressed to 2150 lb. At this pressure it is discharged to the two injection wells and returned to the producing formation through the 5½-in. casing, as well as through the tubing.

V-Type Compressors

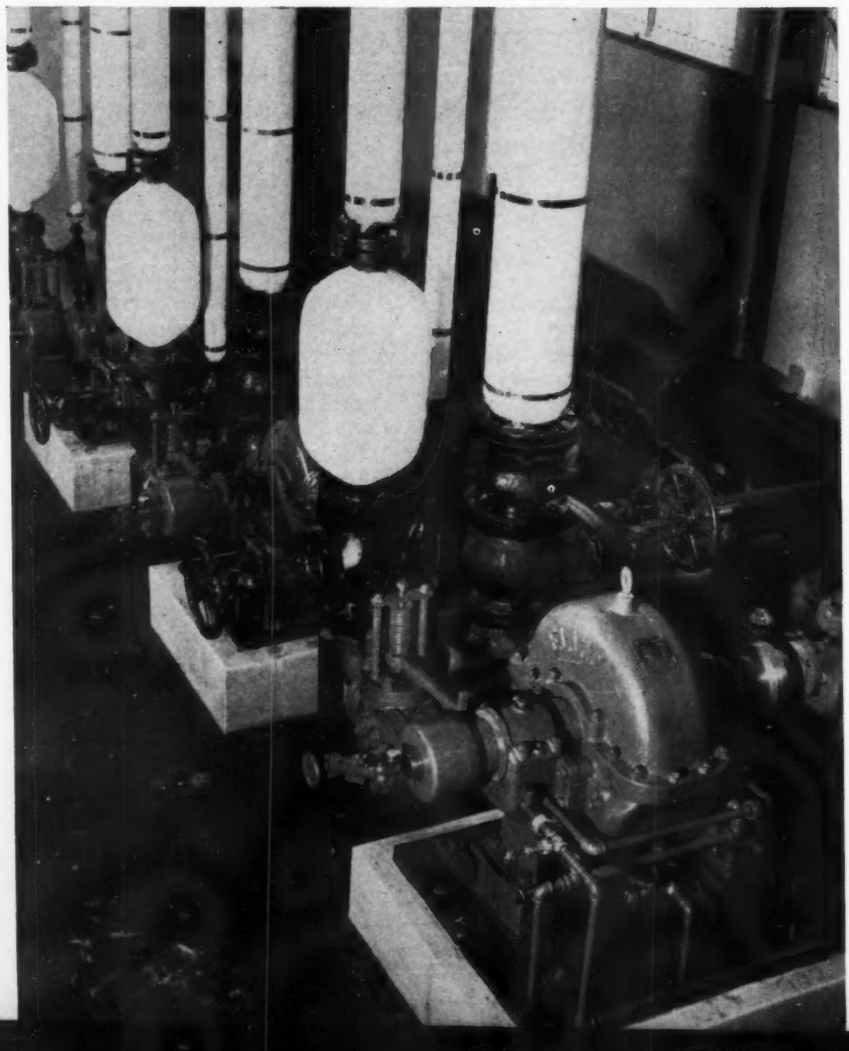
There are two compressor units, each consisting of a 650-hp. (at 300 r.p.m.) vertical V-type, 8-cylinder, 4-cycle single-acting gas engine driving twin horizontal crosshead-type double-acting compressors of 5⅛-in. bore and 15-in. stroke. The bore of the power cylinders is 14½ in. and length of stroke, 18 in. The power cylinders are equipped with alloy cast-iron honed liners, the top and bottom ends of which are sealed with synthetic rubber rings. Each unit is designed for continuous full-load service. The power cylinder heads are of the valve-in-head type and have silchrome inlet and exhaust valves with chromium-plated stems. Valve stem guides and exhaust valve seats are replaceable, and all valve mechanism is enclosed. All power pistons are cooled by an oil spray from the top of the connecting rods. The fuel system consists of a sensitive low-pressure fuel regulator, a fuel gas cock, and a constant quality mixing valve that automatically maintains the mixture at the most economical point at all loads and speeds. The lubrication system is the full force-feed type and consists of a spiral gear oil pump direct-connected to the crankshaft. This



Adjusting one of the many late-type controllers installed in the plant

(Photo by Meisel)

pump provides force-feed lubrication to all main, crank-pin, piston-pin, wrist-pin, crosshead pin, and camshaft bearings, crosshead shoes, and rocker arms. A separate force-feed lubricator has individual adjustable sight-feeds to each compressor cylinder and stuffing-box. An auxiliary drive from the governor drive box on the flywheel end provides a convenient power take-off at a speed of 600 r.p.m. The jacket water system is closed. A centrifugal pump draws water from a surge tank, pumps it through the engine jacket to cooling coils in the base of the cooling tower, and back to the surge tank, a continuous operation. The engines are equipped with mufflers, air cleaners, and lubricating oil filters. In addition to the standard filter with which each engine is equipped, company engineers have installed cotton-waste filters of their own design. These are vertical units 16 in. in diameter by 5 ft. high and are situated outside the compressor building. Used as auxiliaries they assist in minimizing acidity of the oil. Compactness characterizes the compressor units. They have an overall length of 14 ft., overall width of 17 ft. 2 in., and overall height above floor of 12 ft.



A part of the plant's pump equipment

(Photo by Meisel)

Producing Wells

Supplying the plant with gas-distillate are 13 wells and another is soon to be added. Three of these wells produce both oil and gas and in such wells a packer is set between the two producing zones. Casing is perforated opposite the gas zone and gas produced through the annular space between the casing and tubing. Producing wells are 5200-5300 ft. in depth. Gas is received at the plant at a pressure of 2000 lb. and is reduced to 1500 lb. at the absorbers by a reducing valve, as has been previously stated. There are two injection wells, both of which have 5½-in. casing. Gas is returned to the producing zones through the casing as well as through the tubing, and is injected at a pressure of 2150 lb.

Description of Flow

Mineral seal oil is pumped through

NEW PLANT IN LONG LAKE FIELD INSTALLS INGERSOLL-RAND LVG'S

● Two 650 hp. Type LVG gas-engine compressors are the heart of this 50,000,000 cfd. plant. Gas enters the double-acting steel compressor cylinders at 1350 to 1450 lbs. and is discharged at 2150 lbs.

The LVG is the latest addition to the line of Ingersoll-Rand gas engine compressors — *the original line* of V-angle design—the line noted for reliability, economy, accessibility, ease of installation and economy of floor space and foundations.

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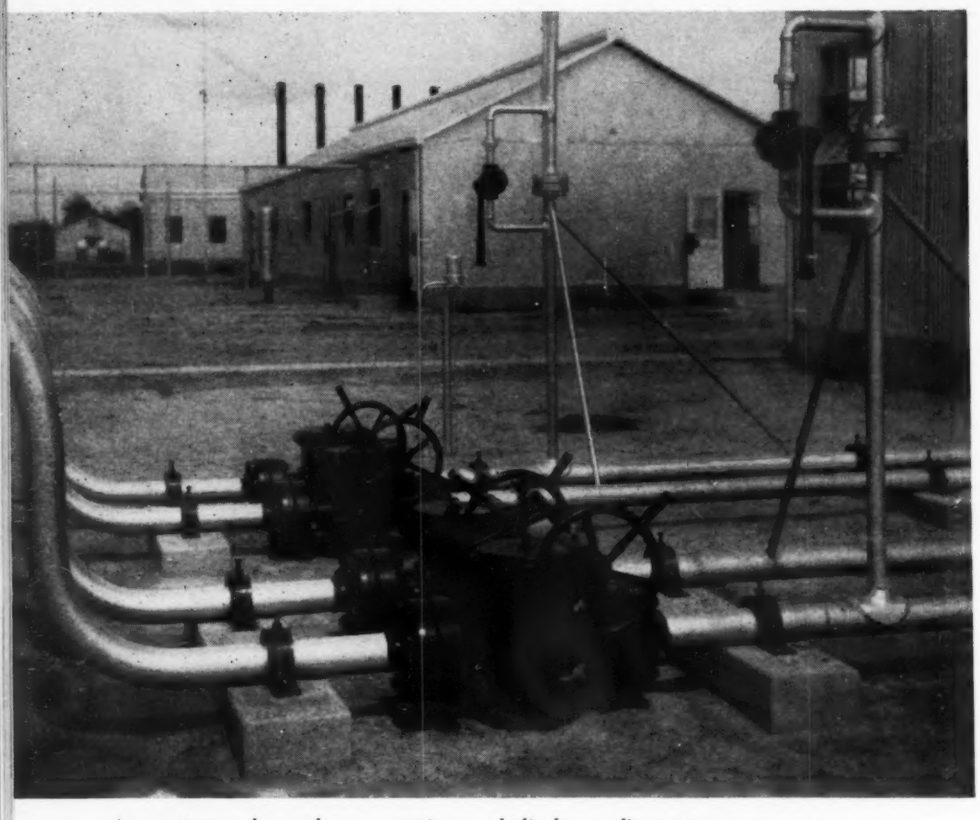
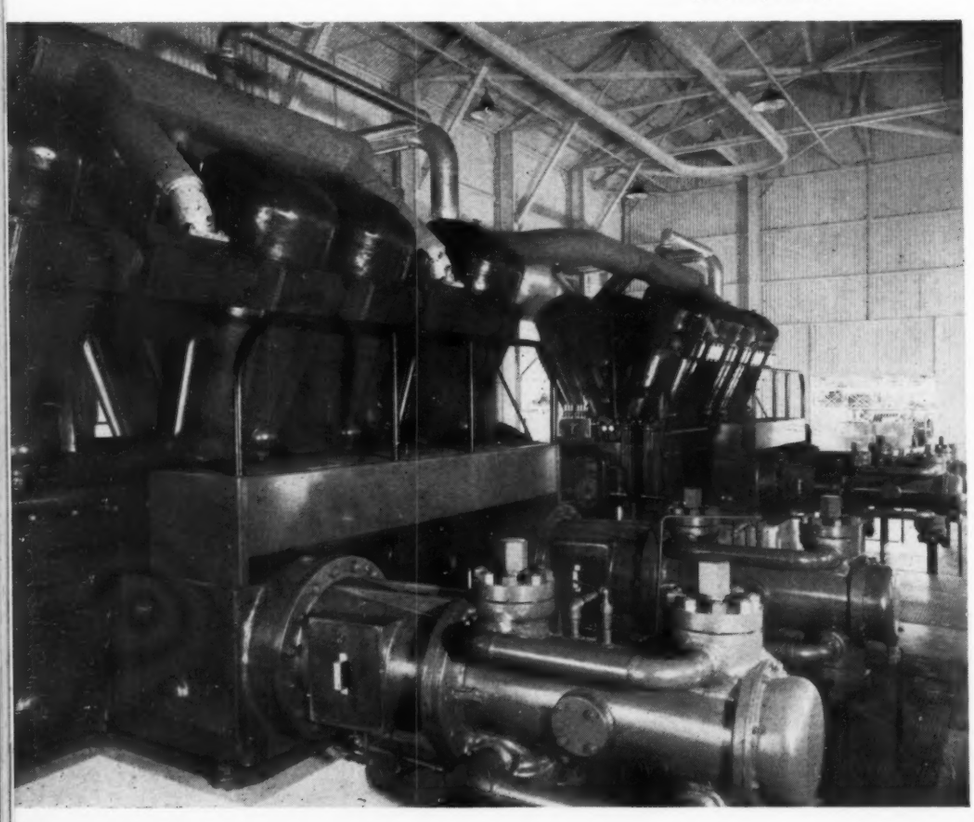


A new-type plug valve on suction and discharge lines to compressors

Two 650-hp., V-type, 8-cylinder, 4-cycle compressor units were installed
(Photo by Meisel)



the two absorbers by a duplex pump driven through a gear by a 125-hp. horizontal steam engine. Discharge to the absorbers is at a pressure of 1500 lb. The rich oil leaves the high-pressure absorbers and is flashed to a pressure of 450-500 lb. in a high-pressure flash column. From this flash column the gas passes through a high-pressure reabsorber. The liquid from the bottom of the high-pressure flash tank and that from the high-pressure reabsorber are flashed to a pressure of 180 lb. in a low-pressure flash column. The gas from the low-pressure flash column goes to the low-pressure reabsorber and the liquid passes on through heat exchangers to the preheater, which operates at a temperature of 400° F., thence to the primary still. This still, which is 54 ft. in height and has 20 trays, operates at 90-lb. pressure and a top temperature of 290° F. Gasoline is taken off this still. Absorption oil and the remaining distillate pass through a preheater to the secondary still. This still also contains 20 trays but is 56 ft. high. The temperature of the preheater is 400° F., the top temperature on the still is 380° F., the operating pressure of the latter being zero lb. per sq. in. From this still kerosine is taken.

The stripped oil gravitates to a surge tank where it is picked up by the hot oil pump and discharged through heat exchangers, cooling coils in the base of the cooling tower, and to the suction of the high-pressure lean oil pump.

When gasoline comes off the primary still at a pressure of 90 lb. it is first cooled in the base of the cooling tower, then passes to the primary still reflux accumulator and to the horizontal stabilizer feed tank. Kerosine from the secondary still is cooled in the cooling tower and passes to a secondary still reflux accumulator before being pumped to storage.

Gasoline is picked up from the stabilizer feed tank and is discharged to the 63-ft., 36-tray stabilizer column. Currently a pressure of 275 lb. and a temperature of 322°F. are being maintained on the stabilizer to produce a product having a 16-lb. Reid vapor pressure. The finished gasoline is trapped from the stabilizer reboiler bottom to storage.

Storage for gasoline and kerosine consists of eight 1000-bbl. horizontal tanks. From these the two products are pumped to an 8-car loading rack. Two pumps driven by 5-hp. motors and having a capacity of 250 gal. per min. each, are provided for this purpose. They are housed separately from

(Continued on Page 61)

Steam is supplied by six 125-hp. boilers

(Continued from Page 58)

the other pumps and are so arranged that each can pump gasoline or kerosine or both products.

A water well, drilled to a depth of 750 ft., supplies the plant with make-up water. Water is brought to the surface by gas-lift and discharged to a 2500-bbl. tank. As the water has a measure of hardness and causes some scale to form in the boilers, equipment is to be installed for its treatment.

The cooling tower is a 15-bay unit, 110 ft. by 26 ft., of the atmospheric type. Its capacity is 3000 gal. per min.

Electricity for the lighting system and for the motors used in the plant is generated by a 220-volt, 40-kva. alternator driven by a 40-hp. steam turbine. As a standby unit a 25-kva. alternator driven by a Ford Mercury engine is provided. This engine is equipped to operate either with gas or gasoline as fuel. The light and power system is a 4-wire arrangement having a total of 220 volts. All wiring is carried in conduits and lights are encased in vapor-tight fixtures.

Steam for the plant is supplied by six 125-hp., high-pressure, locomotive-type boilers, housed in the same building as the electrical-generating plant. Steam is provided at a pressure of 250 lb. Steam lines are carried overhead and are adequately insulated.

Pump Equipment

Other than those used for loading gasoline and kerosine into tank cars, all pumps are housed in one building. In this pump house are the following:

Hot lean oil pump and spare, each a centrifugal unit driven by a 35-hp. steam turbine.

Cold water pump, centrifugal, driven by a 55-hp. turbine, and a duplicate standby.

Stabilizer feed pump, 10 by 7 by 16, reciprocating, turbine driven.

Stabilizer reflux pump, 8 by 6 by 12, reciprocating, connected to a steam turbine.

Stabilizer feed and reflux pump, 10 by 7 by 16, reciprocating, turbine driven.

Rich oil pump on the low-pressure reabsorber, centrifugal, 3300 r.p.m., 145 gal. per min. capacity, driven by a 10-hp. turbine.

The primary still reflux pump and the primary still/rich oil standby unit are of the same style, size, and capacity as the rich oil pump just described.

Secondary still reflux and standby pumps are of the reciprocating type, 5½ by 3½ by 7, turbine driven.

Two high-pressure duplex lean oil pumps, one used as a spare, driven by 125-hp. steam engines.

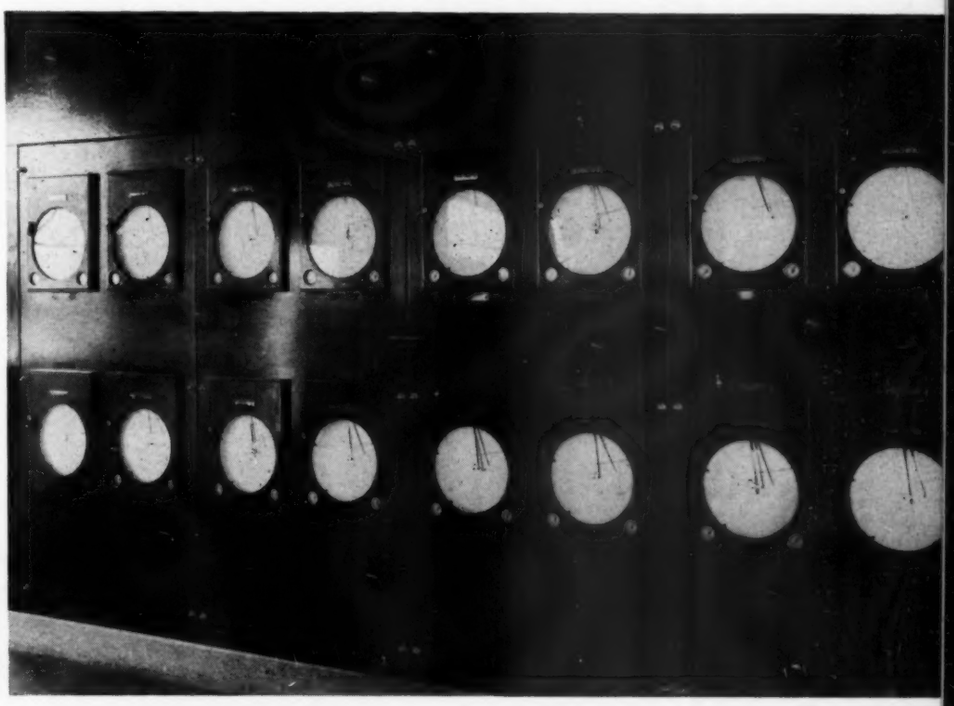
Gas for plant fuel is taken off the two reabsorbers and the stabilizer reflux accumulator.

The main pump room, the compressor building, the boiler house, and the small building housing the two loading pumps are of steel-frame and corrugated-iron construction. Office and warehouse are of frame structure.

Hudson Engineering Corporation, Houston, Texas, designed and constructed the plant for the Hunt Oil Company.

Instrument panel centralizes control of critical operations

(Photo by Meisel)



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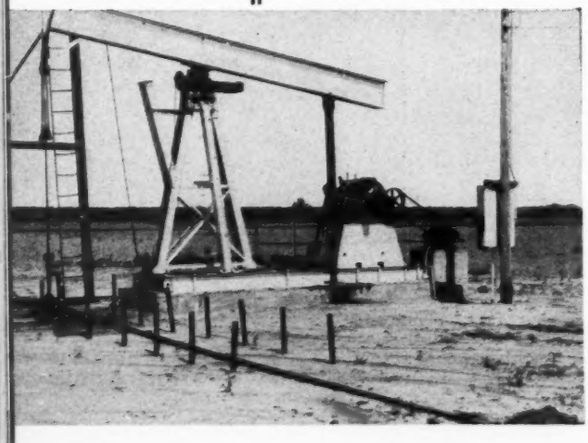

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PETROLEUM ELECTRIC POWER ASSOCIATION

Deepening and Completing a Well in the Lisbon Field, Louisiana—A Study in Modern Coöperative Practice

Part 7

By PAUL D. TORREY, Geologist, The Sloan and Zook Company
and
FRANK H. MILLER, Petroleum Engineer
Lisbon Exploration Company, Inc.

b. Loss of stable condensate. The loss of stable condensate by increased separation pressure for two-stage separation is shown in Fig. 13, and the loss of stable condensate by increased separation pressure for four-stage separation is shown in Fig. 21. In the event injection pressures of as high as 2000 lb. per sq. in. are required for repressuring the Pettit lime, the loss of stable condensate will be very appreciable. The losses that may be expected if the gas is used at high pressure for repressuring are listed in Table 35.

The effects of increased temperatures are evident in the loss of stable condensate in a somewhat similar manner to that shown for natural gasoline in Tables 33 and 34. Data were not available to calculate the loss that would take place at 95°F. for four-stage separation but undoubtedly it will be greater than the loss at 80°F.

c. Production rate. No data can be presented as to the amount of gas and distillate that can be produced from the Vaughn well in relation to decline in bottom-hole pressure until after some production history is available. In like manner, it cannot be stated to what point the bottom-hole pressure can be lowered without bringing about a serious retrograde condensation of liquid fractions in the reservoir. That such condensation in the reservoir will take place as the bottom-hole pressure declines may be reasonably expected, and for this reason it appears certain that pressure maintenance will have to be employed to obtain efficient recovery of condensable hydrocarbons. So long as the Vaughn well is not offset it is probable that moderate withdrawals for a period of several months will not have a serious diminishing effect on the bottom-hole pressure. From data to be presented later it is evident that high production from offsets spaced too closely to the Vaughn well would rapidly deplete the reservoir.

10. Refinery analysis of crude oil. A refinery analysis of some of the first liquid hydrocarbons produced from the Vaughn well is given in Table 36.

The octane number of the cracked gasoline fraction is reported to be 66.2, and such being the case a blending of the straight-run and cracked gasolines would improve the quality of the fuel.

11. Oil and gas reserves. The estimation of oil and gas reserves of a new field are always difficult, and this is particularly true in the Lisbon field where the extent of the structure, the thickness and distribution of the Vaughn sand, and the contents of the reservoir are unknown. It has been pointed out previously that there were good reasons for believing that the Vaughn sand and possibly other Lower Marine sands might thicken to the south and southwest, and that going down dip there was a good possibility that the Vaughn sand might carry oil rather than gas and distillate. These possibilities remain to be verified by the drilling of additional deep wells in the field. For the time being the only safe basis for the estimation of reserves must depend on the conditions encountered in the Vaughn well. Likewise, as the extent of production from the Vaughn sand is unknown, all estimates have been based on units of 640 acres and less. These estimates have been prepared for three different methods of production, which are: (1) estimate of reserves based upon total recovery of gas and distillate with the installation of a pressure maintenance plant and a gasoline recovery plant, and operation of the well at optimum separation pressures; (2) estimate of reserves based upon recovery with pressure maintenance and gasoline plants and operation of well at high separation pressures for the purpose of repressuring, and (3) estimate of reserves based upon recovery with a pressure maintenance plant but without a gasoline plant, and operation of well at high separation pressures for the purpose of repressuring. These estimates are presented in Table 37.

The value of a high-pressure absorption plant should be evident from the foregoing figures. Over one-half of the available condensate will be

Photographs and biographical sketches of the writers of this article can be found on page 155 of the February issue of *The Petroleum Engineer*, in connection with Part 1.

TABLE 35

Loss of stable condensate through high-pressure separation. (700 lb. per sq in. optimum for two-stage separation and 800 lb. per sq. in. optimum for four-stage separation.)

First stage separation pressure, lb. per sq. in.	Two-stage separation			
	65°F.		80°F.	
	MM. cu. ft.	5 MM. cu. ft.	MM. cu. ft.	5 MM. cu. ft.
800	0.10	0.50	0.10	0.50
1000	0.45	2.25	0.50	2.50
1200	0.90	4.50	1.05	5.25
1400	1.45	7.25	1.75	8.75
1600	2.10	10.50	2.55	12.75
1800	2.90	14.50	3.35	16.75
2000	3.50	17.50	4.30	21.50
	Four-stage separation			
800	0	0	0	0
1000	0.20	1.00	0.35	1.75
1200	0.90	4.50	0.95	4.75
1400	1.70	8.50	1.70	8.50
1600	2.50	12.50	2.60	13.00
1800	3.30	16.50	3.40	17.00
2000	4.30	21.50	4.35	21.75

TABLE 36

Refinery analysis of condensate from the Vaughn well

Crude	
Gravity, A.P.I.	54.5
Flash	BRT
Fire	BRT
Viscosity at 50° F.	36 sec.
Viscosity at 100° F.	35 sec.
Pour point	0
B. S. and water	Trace
Sulphur, percent	0.02
Color	Yellow

Products

	Gasoline	Kerosine	Gas oil
Percent yield	59.0	19.0	20.0
Vapor temp., °F.	350	500	
Gravity, °A.P.I.	59.9	46.9	39.7
Flash		130 Tag. cc.	280
Fire			300
Viscosity			46 at 100° F.
P. T.			60
Color	30	25	3½ N.P.A.

A. S. T. M. distillation on gasoline cut

Gravity, °A.P.I.	59.9
Initial boiling point, °F.	118
10 percent	170
20 percent	190
30 percent	207
40 percent	221
50 percent	234
60 percent	245
70 percent	264
80 percent	284
90 percent	309
95 percent	339
End point	380
Recovery percent	97.5
Doctor test	Negative
Octane number	55.5

2.1 cc. tetraethyl lead required to obtain 74 octane number.

Estimated topping and cracking yields

Straight-run gasoline	59.0 percent
Kerosine	19.0 percent
Cracked gasoline	14.0 percent
Fuel oil (11° A.P.I.)	4.0 percent
Gas and loss	4.0 percent

lost if the Vaughn well is operated at a separation pressure of 2000 lb. per sq. in., which may be needed for successful repressuring, but without installing a gasoline extraction plant.

12. Recommended well spacing. Well spacing should be designed to provide a profitable return of the investment involved in oil-field development and at the same time permit an efficient recovery of gas and oil. The estimated recovery and gross value of products from spacing units of 160 acres, 320 acres, and 640 acres are given in Table 38.

The figures presented in Table 38 are not intended to represent an appraisal of the value of the properties or the actual return on investment that may be obtained from wells producing from the Vaughn sand. For this reason royalty, taxes, development cost, including the cost of gasoline and pressure maintenance plants, operating expense, and compounded discount factor have not been taken into consideration. The first purpose of this table is to present additional evidence of the necessity for a pressure maintenance and gasoline recovery installation in order to realize the maximum return from any spacing unit. If pressure maintenance is not employed the recovery of condensate may likely be reduced 30 or 40 percent. The second purpose of the table is to show the fallacy of anticipating profitable recovery from small well-spacing units under the conditions that were found in the Vaughn well.

EDITOR'S NOTE: This article will be concluded in a forthcoming issue.

TABLE 37

Estimation of reserves in the Vaughn Sand for small, adjacent units in the Lisbon field

Constants used in all calculations

(Pressure maintenance plant required for effective recovery. If not installed reduce recovery of distillate from 30 to 40 percent.)
Average thickness of sand—10 ft.
Average porosity of sand—10.5 percent.
Specific gravity of gas—0.70.
Calculated bottom-hole pressure—3985 lb. per sq. in.
Bottom-hole temperature—208° F.
Top-hole temperature used—65° F.*
Top-hole pressure used—15 lb. per sq. in.

*Increased top-hole temperature will materially reduce recovery of liquid fractions.

Calculation of gas reserves for all three methods of operation

NOTE: *The supercompressibility of the gas was not determined for the bottom-hole pressure of 3985 lb. per sq. in. and the bottom-hole temperature of 208° F., and consequently cannot be taken into consideration. At higher temperatures, however, natural gas tends to conform more closely to the gas laws, and such being the case the error introduced may not be serious.*

Formula used:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

where P_1 = bottom-hole pressure
V_1 = bottom-hole volume
T_1 = bottom-hole temperature absolute
P_2 = top-hole pressure
V_2 = top-hole volume
T_2 = top-hole temperature absolute

Actual calculation:

$$\frac{3985 \times (43{,}560 \times 10 \text{ ft.} \times 10.5\% \text{ porosity})}{208° + 460°} = \frac{15 \times V_2}{65° + 460°}$$

$$\frac{3{,}985 \times 45{,}738}{668} = \frac{15\ V_2}{525}$$

$$10{,}020\ V_2 = 95\ 690{,}000{,}000$$

$$V_2 = 9{,}550{,}000 \text{ cu. ft. per acre.}$$

NOTE: *Inasmuch as all calculations are based upon a pressure maintenance installation the total gas content of the reservoir has been calculated. In actual practice a reduction of bottom-hole pressure to 200 lb. absolute might be considered the economic limit for the depth involved.*

Calculation of condensate reserves for three methods of production

(First Method) Estimated total recovery using pressure maintenance, gasoline extraction, and optimum separation pressure.

Total stable condensate by separation and absorption—26.2 bbl. per MM. cu. ft.

NOTE: *See section 7, Production Tests.*

Total stable condensate per acre = 26.2 × 9.550,000
= 250.2 bbl.

NOTE: *It will require approximately 183 cu. ft. or 32.6 bbl. of gas-filled voids in the reservoir under existing bottom-hole pressure and temperature to recover 1 bbl. of distillate.*

(Second Method) Estimated total recovery using pressure maintenance, gasoline extraction, and operating under a separation pressure of 2000 lb. per sq. in. at 65° F. (See Table 35.)

26.2 — 3.5 loss = 22.7 bbl. condensate per MM. cu. ft.
22.7 × 9.550 000 = 216.8 bbl. per acre.

(Third Method) Estimated total recovery using pressure maintenance without a gasoline plant, and operating under a separation pressure of 2000 lb. per sq. in. at 65° F. (See Table 33.)

(26.2 — 3.5) — 9.88 = 12.82 bbl. of condensate per MM. cu. ft.
12.82 × 9.550,000 = 122.4 bbl. per acre.

TABLE 38

Estimated recoveries and gross value of production from different well-spacing units, for the Vaughn Sand in the Lisbon field

	Well-spacing unit		
	160-acre	320-acre	640-acre
First method (Table 37)			
Gas reserves, M. cu. ft.	1,528,000	3,056,000	6,112,000
Value at $0.03 per M. cu. ft.	$45,840	$91,680	$183,360
Condensate recovery, bbl.	40,032	80,064	160,128
Value at $1.20 per bbl.	$48,038	$96,077	$192,154
Total gross value of gas and condensate	$93,878	$187,756	$375,512
Second method (Table 37)			
Gas reserves and value as in first method.			
Condensate recovery, bbl.	34,688	69,376	138,752
Value at $1.20 per bbl.	$41,626	$83,251	$166,502
Total gross value of gas and condensate	$87,466	$174,932	$349,864
Third method (Table 37)			
Gas reserves and value as in first method.			
Condensate recovery, bbl.	19,584	39,168	78,336
Value at $1.20 per bbl.	$23,500	$47,000	$94,000
Total gross value of gas and condensate	$69,340	$138,680	$277,360

P 615.1
P 621.

Laws of Fluid Flow In Rough Pipes

Experimental work extends the determination of friction factor, f, into the region of flow conditions of existing high-pressure transmission lines

PART 5 (Concluded)

By J. NIKURADSE

Summary

The present article deals with turbulent flows of fluids in rough pipes at various relative roughnesses k/r (k = mean roughness elevation, r = radius of pipe). In order to fulfill the assumptions of the mechanics of similarity, such tubes were chosen as experimental tubes, which, including the roughness, had a geometrically similar shape. The roughnesses were produced by the pasting on of sand grains, which themselves had an approximately similar geometric shape and corresponding diameters k. Consequently we have two geometrically similar tubes with geometrically similar wall characteristics, when k/r is maintained constant. It was then established whether, at a certain Reynolds Number, the coefficient of resistance λ was of equal value in these two tubes, and whether the function $\lambda = f$ (Re) resulted in a smooth curve.

It was necessary to investigate furthermore whether the velocity distributions for a relative roughness k/r = constant are similar and in which way they depend on the Reynolds Number. The experiments have shown that such a function $\lambda = f$ (Re) actually exists. The velocity distributions for a relative roughness show a very slight dependence on the Reynolds Number; contrary to this, the form of the velocity distribution is more dependent on the relative roughness, and the velocity distribution becomes more acute with the increase of relative roughness. The testing of whether the Prandtl power curve can also be applied to the velocity distributions in rough tubes, has shown that the velocity distributions can be represented by a power curve of the type $u = ay^n$, in which the exponent n increases from 0.133 to 0.238 with increasing relative roughness.

The experiments were carried out with six different relative roughnesses within the range of the Reynolds Numbers Re = 10^4 to 10^6 and result in a law for the resistance curve, which can be characterized by three different ranges as follows:

In range I for small Reynolds Numbers, the coefficient of resistance in rough tubes is the same as in the case of smooth tubes. In this range the elevations of roughness are located completely within the laminary layer.

In range II (transitional region) an increase is observed in the coefficient of resistance with increasing Reynolds Number. The thickness of the laminary layer is in this case of the same order of magnitude as the elevations of roughness.

Finally, in range III, the coefficient of resistance is independent of the Reynolds Number (quadratic resistance curve). In this case, all elevations of roughness project from the laminary layer, and the simple formula:

$$\lambda = \frac{1}{\left(1.74 + 2\log\frac{r}{k}\right)^2} \quad . \quad (4)$$

holds good for the coefficient of resistance λ.

If we wish to represent all ranges of the resistance curve by only one formula, then we arrange the entire experimental material so as to plot $\frac{1}{\sqrt{\lambda}} - 2\log r/k$ depending on $\log\frac{v^* k}{\nu}$ where $v^* = \sqrt{\frac{\tau_0}{\rho}}$.

Thereby we obtain the general formula:

$$\lambda = \frac{1}{\left(a + b\log\frac{v^* k}{\nu} + 2\log\frac{r}{k}\right)^2} \quad . \quad (11)$$

where a and b are of different values in the different ranges.

For the velocity distribution the following general formula is given:

$$\frac{u}{v^*} = A + B\log\frac{v}{k} \quad . \quad (16a)$$

in which B = 5.75 and A equals 8.48 for the field of the quadratic resistance curve, and in the other fields also depends on $\frac{v^* k}{\nu}$. As a relation between the curve of the velocity distribution and that of resistance, we obtain the formula (20):

$$\frac{u}{v^*} - 5.75\log\frac{v}{k} = \frac{2.83}{\sqrt{\lambda}} - \left(5.75\log\frac{r}{k} - \beta\right) = f\left(\log\frac{\nu}{v^* k}\right) \quad . \quad (20)$$

in which $\beta = 3.75$, and which has been determined from the von Kármán curve of velocity distribution:

$$\frac{U - u}{v^*} = f\frac{y}{r}.$$

From this latter equation and by integration we get:

$$\frac{U - \bar{u}}{v^*} = \beta \quad . \quad (17a)$$

and from this, with the aid of the velocity distribution curve, the relation between the mean velocity $\bar{u}$ and the maximum velocity U, which depends on $\frac{v^* k}{\nu}$, may be plotted.

In conclusion, the mixing path, l, depending on the wall distance, y, was determined from the experiments with the aid of the Prandtl mixing path formula:

$$\frac{\tau}{\rho} = l^2 \left|\frac{du}{dy}\right| \frac{du}{dy} \quad . \quad (27a).$$

For this purpose the formula:

$$\frac{l}{r} = 0.14 - 0.08\left(1 - \frac{y}{r}\right)^2 - 0.06\left(1 - \frac{y}{r}\right)^4 \quad . \quad (29)$$

is given empirically, which holds good only for large Reynolds Numbers and for the entire range of the quadratic resistance curve in which there is no effect of viscosity.

Perhaps no single work, since Weymouth's, has contributed so much of practical value to the knowledge of flow conditions in pipe lines as this paper by Nikuradse. Appearing in *Forschungsheft*, publication of Verein Deutsch Ingenieurs (German Society of Engineers) in 1932, it has been unavailable to American engineers except in the German version. Publication, even seven years after its appearance in Germany, is justified as an answer to the many requests from engineers in this country who desire to avail themselves of the data contained herein.

Due acknowledgment is hereby given to the Panhandle Eastern Pipe Line Company, 90 Broad Street, New York, New York, for permission to publish the English translation of the paper.

Note: Tables 6 to 13, inclusive, will be found on the next succeeding pages.

TABLE 6

$\bar{u}$ cm/s	ν cm²/s	$\frac{dp}{dx}$ dyn/cm³	lg Re	lg (100 λ)	$\frac{1}{\sqrt{\lambda}} - 2\lg r/k$	lg $\frac{v_* k}{\nu}$	$\frac{2{,}83}{\sqrt{\lambda}} - C$	$\frac{\bar{u}}{U}$
			$r/k = 30{,}6$					
		$k = 0{,}04$ cm	$d = 2{,}434$ cm		lg $r/k = 1{,}486$			
24,9	0,0129	0,00507	3,672	0,592	2,09	0,732	9,50	0,792
27,0	0,0129	0,00595	3,708	0,590	2,10	0,766	9,57	0,794
29,6	0,0129	0,0072	3,748	0,592	2,09	0,807	9,54	0,792
30,7	0,0129	0,0078	3,763	0,597	2,06	0,825	9,43	0,793
32,3	0,0129	0,00839	3,785	0,583	2,14	0,839	9,67	0,793
35,5	0,0129	0,0102	3,826	0,585	2,13	0,883	9,62	0,794
39,2	0,0129	0,0126	3,869	0,596	2,07	0,929	9,66	0,792
40,2	0,0129	0,0128	3,881	0,578	2,17	0,933	9,73	0,797
45,0	0,0129	0,0161	3,929	0,578	2,17	0,934	9,74	0,795
45,5	0,0129	0,0162	3,935	0,583	2,14	0,982	9,64	0,795
48,0	0,0123	0,01835	3,978	0,578	2,17	1,032	9,74	0,796
51,6	0,0123	0,0214	4,009	0,585	2,13	1,064	9,62	0,797
56,6	0,0123	0,0258	4,049	0,583	2,14	1,107	9,66	0,795
60,8	0,0123	0,0303	4,079	0,592	2,09	1,140	9,51	0,792
67,4	0,0123	0,0370	4,124	0,590	2,10	1,183	9,53	0,795
68,4	0,0123	0,0390	4,130	0,599	2,05	1,196	9,40	0,791
78,5	0,0123	0,0514	4,190	0,599	2,05	1,255	9,39	0,791
94,2	0,0123	0,0756	4,270	0,609	1,99	1,338	9,24	0,790
98,7	0,0123	0,0840	4,290	0,618	1,94	1,362	9,10	0,788
103	0,0123	0,0912	4,309	0,612	1,97	1,380	9,19	0,790
202	0,0128	0,372	4,584	0,639	1,82	1,667	8,72	0,783
237	0,0128	0,519	4,653	0,644	1,79	1,740	8,69	0,782
300	0,0116	0,840	4,799	0,647	1,78	1,888	8,62	0,784
379	0,0116	1,368	4,900	0,656	1,73	1,993	8,49	0,780
440	0,0116	1,840	4,965	0,656	1,73	2,057	8,49	0,780
470	0,0107	2,080	5,029	0,652	1,75	2,120	8,55	0,781
515	0,0107	2,490	5,068	0,650	1,70	2,158	8,41	0,782
598	0,0107	3,350	5,134	0,650	1,76	2,223	8,58	0,779
664	0,0107	4,14	5,176	0,650	1,76	2,270	8,57	0,783
		$k = 0{,}08$ cm	$d = 4.87$ cm		lg $r/k = 1{,}486$			
70,0	0,0128	0,0222	4,425	0,637	1,83	1,508	8,78	0,785
72,5	0,0128	0,0235	4,440	0,630	1,78	1,519	8,89	0,788
95,4	0,0128	0,0413	4,560	0,637	1,83	1,642	8,79	0,785
113,2	0,0128	0,0595	4,636	0,647	1,78	1,721	8,63	0,785
144	0,0128	0,0983	4,740	0,654	1,74	1,826	8,51	0,778
146	0,0105	0,1010	4,830	0,654	1,74	1,922	8,51	0,782
154	0,0105	0,1175	4,855	0,661	1,70	1,947	8,41	0,778
211	0,0105	0,212	4,990	0,657	1,72	2,083	8,46	0,778
272	0,0105	0,348	5,100	0,652	1,74	2,190	8,54	0,783
374	0,0105	0,663	5,240	0,657	1,72	2,330	8,44	0,782
406	0,0105	0,784	5,275	0,657	1,72	2,367	8,45	0,779
454	0,0105	0,958	5,323	0,647	1,78	2,411	8,61	0,784
640	0,0105	1,945	5,473	0,657	1,72	2,565	8,46	0,780
975	0,0105	4,470	5,655	0,652	1,75	2,745	8,56	0,783
		$k = 0{,}16$ cm	$d = 9.64$ cm		lg $r/k = 1{,}486$			
99	0,0111	0,0235	4,934	0,656	1,73	2,032	8,48	0,783
135	0,0111	0,0436	5,068	0,657	1,72	2,167	8,47	0,779
171	0,0111	0,0706	5,170	0,659	1,71	2,271	8,43	0,781
193	0,0111	0,0903	5,223	0,656	1,73	2,324	8,49	0,779
207	0,0111	0,102	5,255	0,652	1,75	2,350	8,55	0,781
246	0,0108	0,146	5,342	0,657	1,72	2,439	8,45	0,780
248	0,0108	0,148	5,344	0,657	1,72	2,441	8,47	0,778
269	0,0108	0,175	5,394	0,659	1,71	2,479	8,43	0,779
300	0,0108	0,218	5,428	0,659	1,71	2,526	8,43	0,783
312	0,0108	0,236	5,444	0,661	1,70	2,545	8,40	0,779
368	0,0108	0,325	5,516	0,657	1,72	2,614	8,48	0,781
390	0,0108	0,367	5,541	0,659	1,71	2,639	8,44	0,778
406	0,0108	0,394	5,559	0,657	1,72	2,655	8,48	0,782
485	0,0090	0,568	5,776	0,659	1,71	2,814	8,44	0,779
603	0,0090	0,879	5,810	0,659	1,71	2,909	8,45	0,782
682	0,0090	1,120	5,863	0,657	1,72	2,961	8,47	0,779
769	0,0090	1,430	5,916	0,659	1,71	3,014	8,43	0,783
855	0,0090	1.720	5,962	0,650	1,76	3,054	8,57	0,780
934	0,0090	2,118	6,000	0,659	1,71	3,100	8,45	0,778

Tables 6 and 7 show experimental data for r/k of 30.6 and 15, respectively

TABLE 7

$\bar{u}$ cm/s	ν cm² s	$\frac{dp}{dx}$ dyn/cm³	lg Re	lg (100 λ)	$\frac{1}{\sqrt{\lambda}} - 2\lg r/k$	lg $\frac{v_* k}{\nu}$	$\frac{2{,}83}{\sqrt{\lambda}} - C$	$\frac{\bar{u}}{U}$
			$r/k = 15$					
		$k = 0{,}08$ cm	$d = 2{,}412$ cm		lg $r/k = 1{,}176$			
30,8	0,0126	0,00995	3,770	0,696	2,14	1,188	9,69	0,772
34,5	0,0126	0,01260	3,820	0,699	2,13	1,239	9,66	0,772
37,4	0,0126	0,01505	3,855	0,707	2,09	1,276	9,57	0,767
42,0	0,0126	0,01920	3,905	0,712	2,06	1,317	9,46	0,775
46,6	0,0126	0,02392	3,955	0,717	2,04	1,377	9,40	0,769
51,0	0,0123	0,02950	4,000	0,730	1,97	1,435	9,23	0,765
56,0	0,0123	0,03600	4,041	0,734	1,94	1,477	9,14	0,765
60,6	0,0123	0,04220	4,076	0,736	1,94	1,511	9,13	0,767
61,2	0,0123	0,0439	4,079	0,744	1,90	1,520	9,03	0,763
66,4	0,0123	0,0526	4,114	0,751	1,87	1,559	8,93	0,760
69,4	0,0123	0,0559	4,133	0,740	1,92	1,572	9,06	0,764
77,0	0,0123	0,0695	4,179	0,744	1,92	1,619	9,06	0,765
80,0	0,0123	0,0767	4,196	0,754	1,85	1,641	8,89	0,760
95,0	0,0123	0,1097	4,270	0,760	1,82	1,718	8,80	0,756
99,5	0,0123	0,1192	4,290	0,756	1,84	1,737	8,85	0,761
105,0	0,0123	0,1370	4,314	0,769	1,78	1,767	8,69	0,758
111,5	0,0123	0,1526	4,340	0,763	1,80	1,791	8,74	0,759
118,0	0,0123	0,1765	4,366	0,778	1,74	1,822	8,54	0,757
124,0	0,0123	0,1930	4,386	0,772	1,77	1,841	8,64	0,756
131,0	0,0123	0,2 47	4.410	0.772	1,77	1,865	8,64	0,758
133,4	0,0121	0,2280	4,425	0,782	1,72	1,884	8,49	0,755
149,0	0,0123	0,282	4,466	0,785	1,74	1,924	8,54	0,755
169,0	0,0123	0,364	4,520	0,780	1,73	1,979	8,53	0,758
196,5	0,0122	0,493	4,590	0,781	1,72	2,049	8,52	0,755
214	0,0121	0,580	4,630	0,777	1,75	2,087	8,56	0,756
266	0,0121	0,900	4,725	0,780	1,73	2,184	8,54	0,756
325	0,0120	1,350	4,811	0,781	1,72	2,278	8,52	0,753
364	0,0120	1,680	4,865	0,777	1,74	2,322	8,55	0,755
375	0,0118	1,776	4,885	0,776	1,75	2,342	8,58	0,756
447	0,0117	2,540	4,965	0,779	1,73	2,422	8,54	0,756
484	0,0117	2,982	5,000	0,781	1,72	2,458	8,52	0,754
532	0,0117	3,611	5,042	0,780	1,72	2,500	8,51	0,754
560	0,0108	4.019	5,098	0,781	1,71	2,566	8,46	0,752
640	0,0108	5,100	5,155	0,778	1,74	2,608	8,54	0,756
675	0,0108	5,809	5,179	0,781	1,72	2,636	8,52	0,756
788	0,0098	7,909	5,285	0,779	1,73	2,746	8,54	0,755
		$k = 0{,}16$ cm	$d = 4{,}82$ cm		lg $r/k = 1{,}176$			
75,5	0,0132	2,91	4,440	0,775	1,75	1,899	8,59	0,756
86,5	0,0132	3,82	4,500	0,777	1,75	1,957	8,55	0,755
95,0	0,0132	4,60	4,540	0,778	1,73	1,998	8,54	0,756
108,0	0,0132	5,96	4,596	0,780	1,72	2,055	8,53	0,758
128,5	0,0128	8,42	4.685	0,781	1,72	2,144	8,52	0,755
150,0	0,0128	11,50	4,722	0,777	1,75	2,210	8,55	0,757
184,0	0,0127	17,30	4,845	0,775	1,75	2,300	8,59	0,757
193,5	0,0126	19,10	4,869	0,778	1,73	2,327	8,54	0,755
212	0,0120	23,00	4,929	0,780	1,72	2,391	8,51	0,755
218	0,0118	24,2	4,949	0,779	1,73	2,409	8,54	0,754
246	0,0118	30,9	5,002	0,777	1,74	2,460	8,53	0,756
248	0,0118	31,4	5,005	0,775	1,75	2,464	8,59	0,754
254	0,0098	33,0	5,097	0,778	1,73	2,555	8,54	0,755
280	0,0098	40,0	5,139	0,783	1,72	2,599	8,49	0,755
291	0,0098	43.2	5,156	0,784	1,71	2,618	8,47	0,756
337	0,0098	58,0	5,220	0,777	1,74	2,677	8,53	0,755
350	0,0098	62,5	5,236	0,780	1,73	2,695	8,54	0,757
406	0,0096	84,0	5,310	0,778	1,73	2,767	8,54	0,756
456	0,0096	106,0	5,360	0,775	1,75	2,816	8,59	0,758
512	0,0096	134,0	5,410	0,780	1,72	2,870	8,51	0,755
556	0,0096	158,0	5,446	0,780	1,73	2,906	8,54	0,758
568	0,0096	165,0	5,455	0,777	1,75	2,914	8,55	0,755
652	0,0096	217,0	5,515	0,781	1,72	2,976	8,51	0,755
750	0,0098	287,0	5,567	0,778	1,74	3,030	8,54	0,752
834	0,0098	355,0	5,613	0,780	1,73	3,073	8,51	0,754
996	0,0098	506,0	5,690	0,784	1,71	3,152	8,47	0,753
1018	0,0072	530,0	5,834	0,781	1,73	3,293	8,51	0,755
1135	0,0072	657,0	5,882	0,777	1,75	3,338	8,55	0,756
1360	0,0072	944,0	5,959	0,778	1,74	3,417	8,54	0,754
1520	0,0072	1180,0	6.008	0,780	1.73	3,475	8,54	0,750
976	0,0076	497,0	5,793	0,780	1,72	3,255	8,52	0,755
1130	0,0076	652,0	5,857	0,777	1,74	3,314	8,53	0,756
1342	0,0076	918,0	5,930	0,778	1,74	3,387	8,54	0,758
1526	0,0076	1190,0	5,987	0,780	1,73	3,446	8,54	0,754

TABLE 8

$r/k = 507$

d cm	9,94		9,94		9,94		9,94		9,94		9,94		9,94				
u cm/s	27		58,5		119,4		217		516		720		838				
$10^2 \nu$ cm^2/s	1,18		1,18		1,14		1,16		1,20		1,05		0,86				
10^{-3} Re	22,7		49,0		106		186		427		680		970				
v_o	1,514		3,0		5,74		10,2		24,6		35,5		41,7				
$\lg \frac{v_o k}{\nu}$	0,106		0,388		0,702		0,938		1,303		1,53		1,666				
$\frac{u}{v_o} - 5{,}75 \lg y/k$	6,3		7,8		9,12		9,52		9,28		9,0		8,68				
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$			
0,00	14,8	—	32,2	—	56,0	—	98,0	—	265,0	—	422	—	523	—			
0,02	19,0	29,65	41,5	61,2	84,0	122,00	150	225	364	585	520	843	608	1022			
0,04	21,2	17,21	45,6	32,6	94,0	64,0	165	116	402	306	573	444	670	526			
0,07	23,0	9,46	49,7	19,0	101,3	38,0	180	69	432	178	625	256	725	309			
0,10	24,3	6,82	52,2	13,94	106,2	27,3	190	50	456	129	652	182	761	222			
0,15	25,8	4,86	55,1	10,00	112,0	19,7	201	36	487	90	689	128	803	153			
0,20	26,8	4,09	57,3	8,13	116,5	16,3	208	29,3	505	72	719	101	832	119			
0,30	28,3	2,80	60,5	5,79	123,0	11,4	220	20,8	531	51	758	72	874	84			
0,40	29,5	2,20	63,0	4,47	128,0	9,23	230	15,9	552	38,7	788	55	912	64			
0,50	30,4	1,80	64,8	3,56	132,0	7,28	237	13,1	568	31,8	812	45	940	52,5			
0,60	31,2	1,51	66,4	3,05	135,0	6,04	242,5	10,8	581	26,2	832	37	960	43,6			
0,70	31,8	1,21	67,7	2,47	137,6	4,80	247,5	8,75	591	21,4	848	30	978	35,5			
0,80	32,35	0,98	68,8	1,97	139,5	3,82	251,0	7,01	600	17,0	861	24	992	28,4			
0,90	32,75	0,68	69,7	1,35	140,8	2,65	253,5	4,74	606	11,6	871	16,5	1003	19,2			
0,96	32,90	0,80	70,1	0,83	141,2	1,64	254,5	2,93	611,2	7,3	875	10,2	1008	12,0			
0,98	32,95	0,42	70,2	0,54	141,3	1,16	254,8	2,08	611,6	5,2	876	7,3	1010	8,7			
1,00	33,0	—	70,3	—	141,4	—	255,0	—	612,0	—	877	—	1011	—			

TABLE 9

$r/k = 252$

d cm	4,924		4,924		4,924		4,924		4,924		4,924						
u cm/s	50,5		122		253,5		486		940		1127						
$10^2 \nu$ cm^2/s	1,17		1,17		1,205		1,19		1,20		0,89						
10^{-3} Re	21,4		51,0		103,5		202		344		624						
v_o	2,87		6,4		13,1		25,45		45,8		61,0						
$\lg \frac{v_o k}{\nu}$	0,391		0,728		1,032		1,321		1,573		1,826						
$\frac{u}{v_o} - 5{,}75 \lg y/k$	7,7		9,10		8,56		9,3		8,9		8,6						
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$					
0,00	24	—	72,0	—	120	—	210	—	328	—	532	—					
0,02	35	112	86,0	285	170	565	332	1145	583	2106	794	2954					
0,04	39	60	94,2	139	192	292	374	600	658	1111	875	1526					
0,07	42,7	35	101,5	83	209	172	410	346	717	648	951	895					
0,10	45,2	26	107,0	60	221	125	432	254	759	462	1000	643					
0,15	47,8	18	113,0	42	234	91	456	179	804	324	1062	443					
0,20	49,7	14,8	117,7	34	244	73	478	144	840	260	1107	346					
0,30	52,8	10,4	125,8	25	262	52	506	103	892	184	1178	247					
0,40	55,0	8,26	131,0	18,9	273	40	528	78	930	142	1225	188					
0,50	56,8	6,80	134,7	15,6	282	33	545	64	961	118	1266	154					
0,60	58,3	5,80	138,0	12,9	290	27	560	53	986	96	1303	127					
0,70	59,5	4,60	141,0	10,5	296	21,8	569	43	1006	78	1330	104					
0,80	60,5	3,70	143,3	8,2	301	17,2	578	34,5	1024	62	1350	83					
0,90	61,2	2,56	144,8	5,7	303,5	12,0	584	23,6	1036	42	1366	56					
0,96	61,6	1,86	145,6	3,54	304,8	7,4	588	14,6	1040	28	1369	35					
0,98	61,6	1,11	145,7	2,50	305,2	5,2	589,2	10,4	1042	18,7	1372	25					
1,00	61,7	—	145,8	—	305,5	—	590,0	—	1043	—	1373	—					

TABLE 10

$r/k = 126$

d cm	2,474		2,474		2,474		2,474		9,92		9,92		9,92		9,92		
u cm/s	81,8		117		238		380		205		374		575		820		
$10^2 \nu$ cm^2/s	1,21		1,22		1,17		1,17		0,68		0,89		0,89		0,85		
10^{-3} Re	16,7		23,7		50,5		112		231		417		640		960		
v_o	4,90		6,7		13,25		30,8		12,0		22,28		34,3		49,0		
$\lg \frac{v_o k}{\nu}$	0,606		0,731		1,045		1,413		1,734		2,000		2,188		2,361		
$\frac{u}{v_o} - 5{,}75 \lg y/k$	8,75		9,14		9,55		9,35		8,75		8,50		8,35		8,38		
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	
0,00	47	—	52,0	—	109	—	202	—	84	—	233	—	352	—	366	—	
0,02	59	370	79,0	527	159	1160	368	2660	135	271	250	516,0	383	794	557	1670	
0,04	66	198	89,4	277	181	570	416	1385	152	138	284	270	436	397	619	616	
0,07	71,1	119	98,4	164	199	340	454	818	167	82	312	158	476	237	676	380	
0,10	74,8	87	103,6	121	210	250	478	597	178	59	331	113	505	165	718	262	
0,15	79,8	61	110,0	87	223	179	513	425	189	41	350	80	536	120	760	181	
0,20	82,9	49	115,0	71	232	145	532	343	199	33,5	366	62	564	95	798	138	
0,30	88,0	35	121,8	49	245	103	565	243	211	23,7	390	44	597	66	852	96	
0,40	92,0	27	126,6	39	255	79	588	187	222	18,2	407	34	619	51	887	74	
0,50	95,2	23	130,3	32	263	66	606	154	229,5	14,9	419	28	640	42	916	60	
0,60	97,7	19,2	133,6	27	269,3	55	620	128	235,0	12,2	431	23	657	34	939	50	
0,70	99,6	15,7	136,4	21,7	275,0	44	633	104	240,5	10,0	439	19	667	27	959	41	
0,80	100,6	12,3	138,6	17,3	280,0	35	644	82	246,0	7,6	448	14,1	678	21	979	31	
0,90	101,4	8,6	140,7	12,1	284,0	24	652	55	248,4	5,5	453	10,3	690	15,2	988	22,5	
0,96	102,0	5,3	141,6	7,4	285,7	15	655	35	249,5	3,4	456	6,4	696	9,5	994	14,2	
0,98	102,1	3,7	141,8	5,2	286,2	10,6	656	25	249,8	2,4	457	4,6	698	6,7	996	10,0	
1,00	102,2	—	142,0	—	286,8	—	657	—	250,0	—	458	—	701	—	998	—	

TABLE 11

$r/k = 60$

d cm	2,434		2,434		2,434		2,434		9,8		9,8		9,8				
u cm/s	96,2		147,6		330,0		544,0		309		514		774				
$10^2 \nu$ cm^2/s	1,21		1,22		1,15		1,14		1,12		1,15		1,12				
10^{-3} Re	15,3		29,5		70		116		271		438		677				
v_o	4,75		9,22		21,6		36,2		20,72		34,4		51,9				
$\lg \frac{v_o k}{\nu}$	0,903		1,180		1,574		1,809		2,164		2,378		2,568				
$\frac{u}{v_o} - 5{,}75 \lg y/k$	9,50		9,55		9,09		8,7		8,50		8,48		8,44				
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$			
0,00	34,0	—	62	—	125	—	207	—	152	—	198	—	250	—			
0,02	50,6	369	95	760	211	3350	392	3140	193	471	316	812	475	1240			
0,04	57,0	188	110,5	390	250	950	436	1592	224	246	370	420	557	640			
0,07	62,5	115	121,0	238	277	575	464	960	245	143	411	246	624	373			
0,10	66,4	83	128,5	172	293	422	496	687	266	104	442	175	666	268			
0,15	71,0	59	137,0	123	314	300	520	487	286	74	474	125	714	189			
0,20	74,0	50	143,0	100	330	255	538	400	300	59	500	98	753	146			
0,30	78,0	34	153,0	70	352	171	565	283	323	42	538	70	793	105			
0,40	82,4	27	160,5	56	368	133	609	214	349	32	562	53	848	80			
0,50	85,0	22	166,0	45	381	109	626	179	353	26,4	582	44	879	65			
0,60	87,0	17,5	170,7	38	393	91	642	148	382	22,0	600	36,5	904	54			
0,70	89,0	14,9	174,5	30,7	402	73	653	120	370	18,0	616	31,0	925	43			
0,80	90,6	12,9	177,5	24,2	409	58	662	95	378	14,3	628	24,0	941	35			
0,90	92,2	8,3	180,0	16,8	416	40	665	65	384	9,6	636	16,0	965	24			
0,96	92,7	5,1	181,5	10,4	418	25	666	40	387	6,0	640	10,0	982	15			
0,98	92,8	3,6	182,0	7,2	419	17,4	666,5	28	387,5	4,3	641,4	7,1	994	10,7			
1,00	93,0	—	182,5	—	419,5	—	667	—	388,0	—	642,0	—	996	—			

TABLE 12

$r/k = 30{,}6$

d cm	2,434		2,434		2,434		2,434		4,87		4,87		9,84				
u cm/s	61		116,5		217,5		450		420		796		734				
$10^2 \nu$ cm^2/s	1,225		1,23		1,21		1,07		1,05		1,046		1,11				
10^{-3} Re	12,1		23		43		104		195		372		638				
v_o	4,25		8,3		16,2		34,8		31,9		60		55,7				
$\lg \frac{v_o k}{\nu}$	1,140		1,428		1,729		2,114		2,389		2,661		2,906				
$\frac{u}{v_o} - 5{,}75 \lg y/k$	9,6		9,16		8,7		8,50		8,48		8,42		8,50				
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$			
0,00	20,0	—	38,0	—	61	—	199	—	112	—	245	—	225	—			
0,02	36,5	332	67,5	680	128	1390	258	3300	215	1465	461	2980	430	1444			
0,04	43,2	171	80,9	345	156	706	328	1610	270	784	585	1518	500	728			
0,07	48,5	106	91,7	208	173	426	367	960	325	452	610	876	570	419			
0,10	51,5	74	98,5	152	185	310	395	696	351	326	660	628	616	302			
0,15	56,0	51,4	106,4	109	200	223	424	491	380	230	718	438	670	209			
0,20	59,0	43,0	113,0	89	211	181	447	401	404	185	766	344	715	162			
0,30	64,0	30,6	121,4	62	228	135	484	284	440	131	833	245	777	115			
0,40	67,4	23,8	128,0	49	242	99	509	219	467	100	880	188	819	88			
0,50	70,0	19,7	132,5	40,0	252	82	531	178	489	83	918	154	853	72			
0,60	72,0	16,8	136,5	33,6	261	67	551	148	507	68	950	126	881	59			
0,70	73,9	13,5	140,0	27,0	267	54	568	120	519	55	976	104	904	49			
0,80	75,6	10,8	142,6	21,5	272	43,4	580	95	530	44	994	83	925	39			
0,90	76,6	7,5	144,8	15,0	276	30,0	587	64	539	30	1008	57	940	26			
0,96	77,0	4,6	145,6	9,2	278	18,4	590	40	541	18,6	1016	35	948	16,5			
0,98	77,1	3,3	145,8	6,8	278,6	13,0	591	30	542	13,2	1017	25	951	11,7			
1,00	77,2	—	146,0	—	279,0	—	592	—	543	—	1018	—	952	—			

TABLE 13

$r/k = 15$

d cm	2,412		2,412		2,412		2,412		2,412		4,82						
u cm/s	57,2		112		215		524		956		873						
$10^2 \nu$ cm^2/s	1,225		1,23		1,21		1,17		1,17		0,98						
10^{-3} Re	11,3		22,2		43		108		197		430						
v_o	4,74		9,06		18,87		46,6		85		76,1						
$\lg \frac{v_o k}{\nu}$	1,491		1,802		2,085		2,504		2,763		3,00						
$\frac{u}{v_o} - 5{,}75 \lg y/k$	9,20		8,7		8,44		8,35		8,46		8,50						
y/r	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$	u cm/s	$\frac{du}{dy}$					
0,00	17,0	—	30,0	—	62	—	170	—	302	—	205	—					
0,02	33,9	480	62,0	800	107	1630	270	4260	532	8000	450	3850					
0,04	39,6	180	73,0	420	136	856	320	2200	628	4235	549	1986					
0,07	44,6	120	86,0	248	158	509	367	1298	710	2440	643	1140					
0,10	48,5	91	94,0	181	174	360	406	940	767	1770	702	830					
0,15	52,9	61,6	102,5	129	191	265	456	667	846	1267	773	578					
0,20	56,2	47,8	109,5	104	205	217	492	544	910	978	830	457					
0,30	61,0	36,2	120,0	74	228	148	545	379	1006	699	917	321					
0,40	64,7	27,0	127,5	57	243	115	585	290	1080	530	978	246					
0,50	67,7	21,0	133,5	47	253	96	617	239	1143	429	1027	201					
0,60	70,0	18,2	138,5	40	263	79	647	199	1195	329	1070	166					
0,70	72,0	15,0	142,0	32	271	64	660	160	1237	290	1107	136					
0,80	73,8	12,4	145,5	25	277	52	689	128	1267	230	1137	108					
0,90	74,8	9,2	148,0	17,6	283	35,5	701	86	1290	160	1162	74					
0,96	75,6	7,4	149,5	10,8	285	22,0	704	54	1296	101	1172	47					
0,98	75,9	6,2	149,8	7,6	286	15,6	706	38	1298	72	1174	33					
1,00	76,0	—	150,0	—	286,5	—	707	—	1300	—	1178	—					

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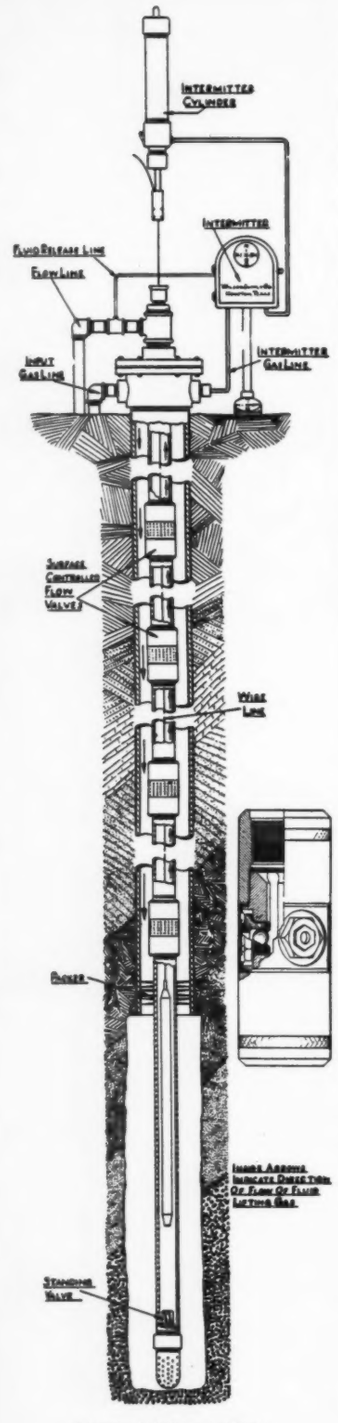
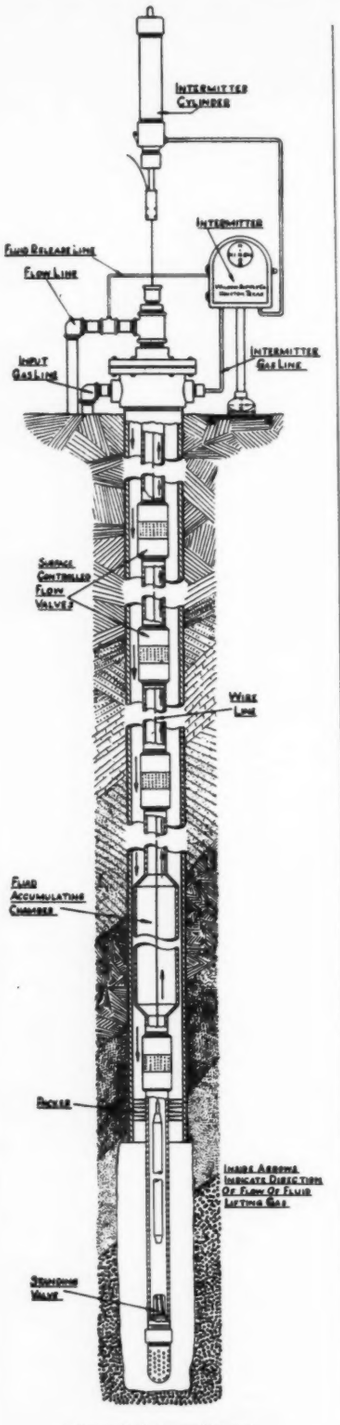
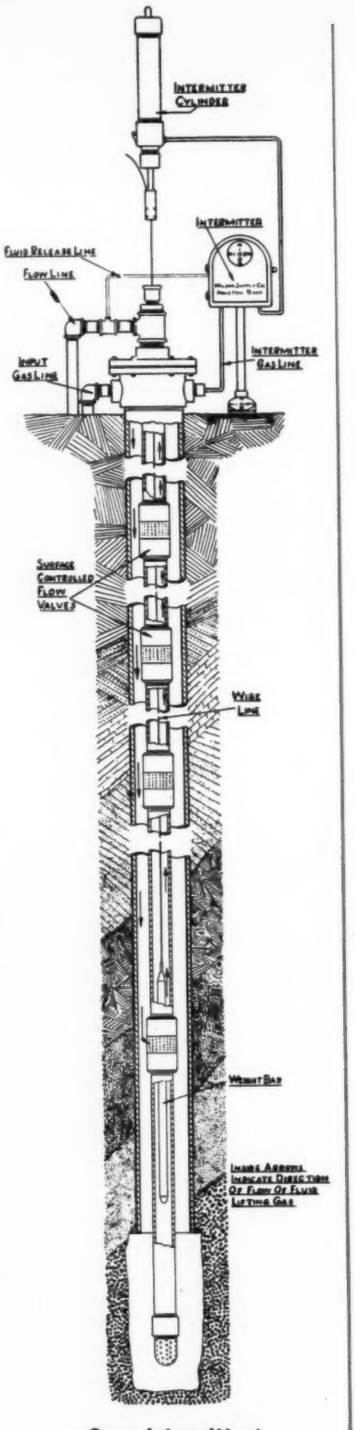


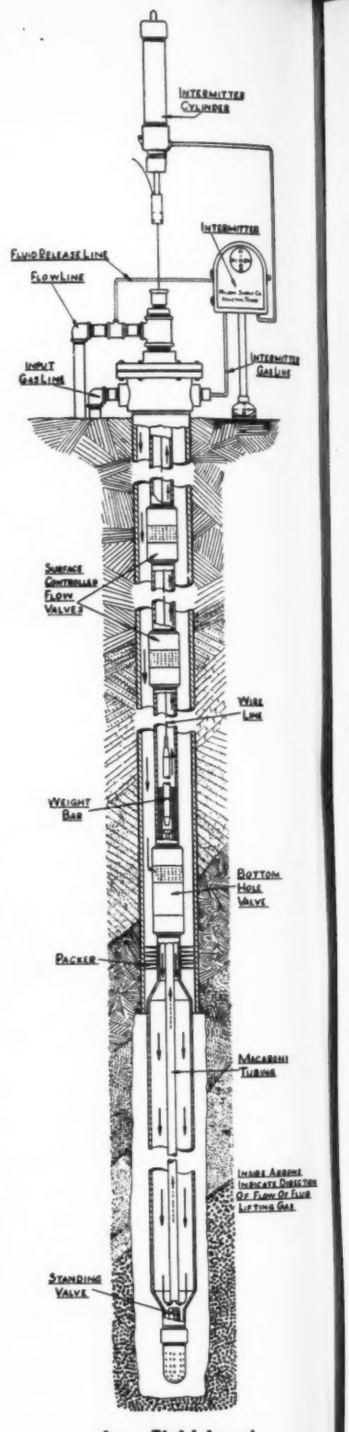
Closed Intermittent Installation



Closed Intermittent Installation with Fluid Accumulating Chamber



Open Intermittent Installation



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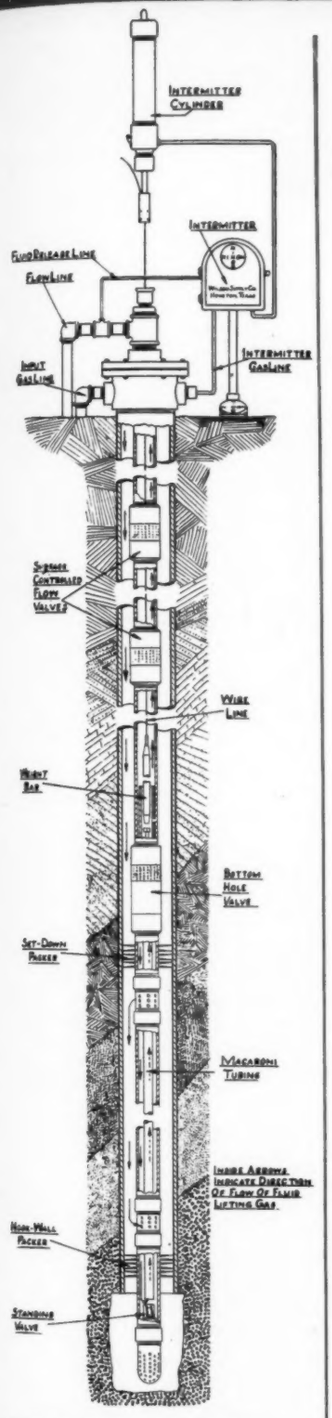
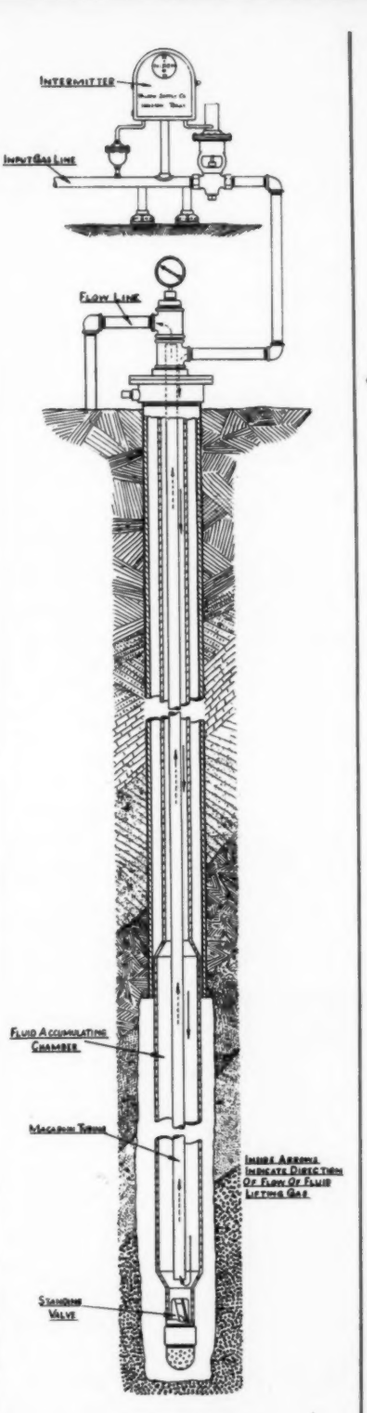
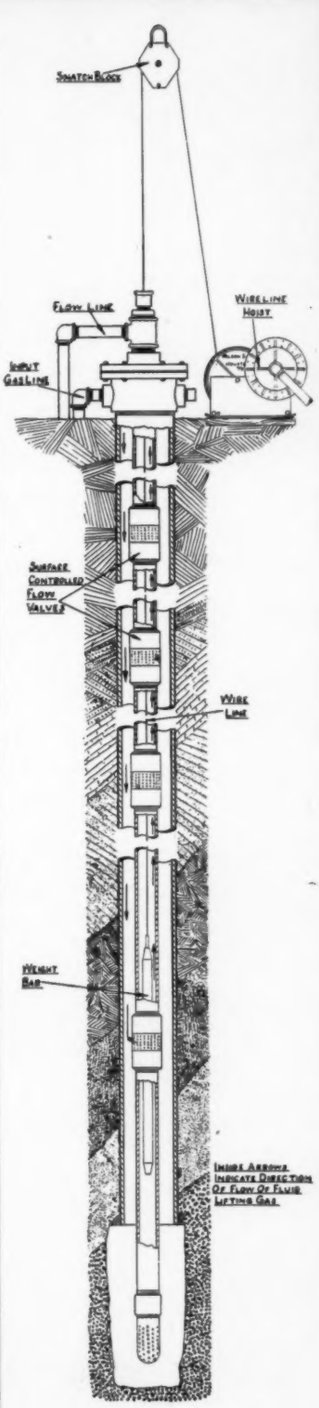


Double Packer Installation . . . Casing used as Fluid Accumulating Chamber



Shallow Well Installation



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High-Pressure Spell Defeat

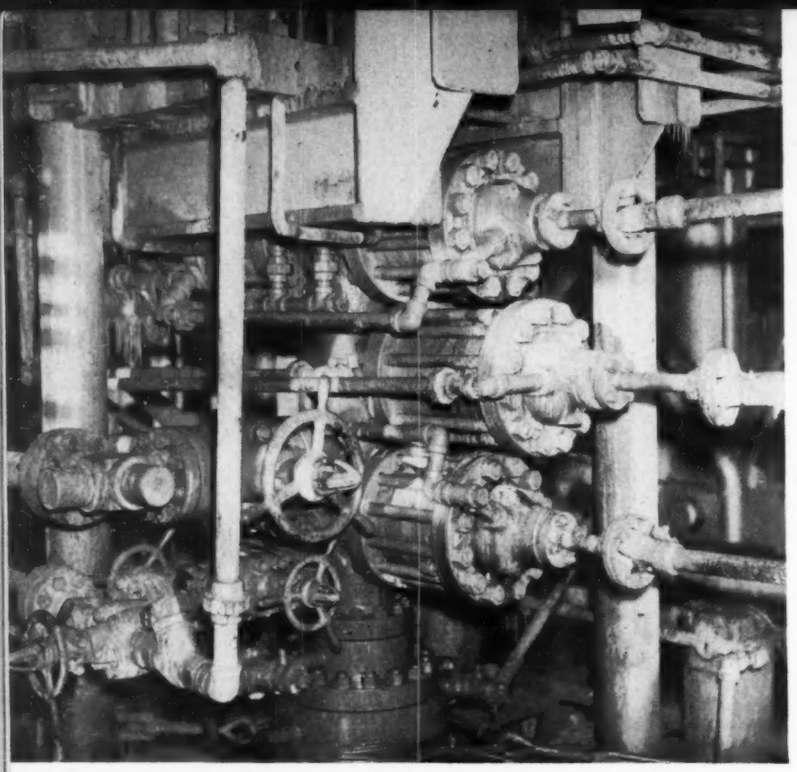


Fig. 1. Three blowout preventers were welded together to save headroom

By M. L. CASHION

Assistant Superintendent of Production,
Houston Production District,
Gulf Oil Corporation

WHEN a drilling well encounters high-pressure salt water flows, it usually means abandonment of the operation if only orthodox methods are employed in an effort to combat such flows. Because this obstacle has been the direct cause of discontinuing many tests that might otherwise have proved productive and because in many wells to be drilled in the future, particularly in the deep tests of the Gulf Coast and elsewhere, salt water under high pressure is sure to be encountered, more than ordinary importance is attached to the procedure by which a strong salt water flow in a Gulf Coast well was successfully combated, thus enabling completion of drilling to the contemplated depth.

The well in question, Lake Borgne 4-RR State, was drilled by Gulf Oil Corporation in Lake Borgne, St. Bernard Parish, approximately 25 miles east of New Orleans, Louisiana. Offshore 8 miles and accessible only by boat, the drilling equipment was definitely of the marine type, employing submersible steel barges and auxiliary piling in the general arrangement that typifies so many Gulf Coast drilling operations.

Prior to beginning the work of drilling ahead against the salt water flow, there was little of unusual interest to distinguish Lake Borgne 4-RR State from other deep tests on the Gulf Coast except that it was scheduled to be drilled to a depth of 12,000 ft. Important, however, in view of the achievements here described, is the fact that 20 tests in the same general area had previously been abandoned because of inability to cope with the salt water flow always encountered under excessive pressure at depths of about 10,000 ft.

Reviewing briefly the events prior to the work of interest, the well was spudded-in during the late summer of 1938. Consequently, drilling had been in progress approximately a year before the salt water formation was encountered at a depth of 10,630 ft. A string of 10-in. O. D. casing had been set and cemented previously at a depth of 8142 ft. Salt water flowing at high pressure from the 2 ft. of formation cored had caused the 15-lb. mud to be ejected from the hole. When the bit was raised to the bottom of the 10-in. casing to permit conditioning of the mud to increase its weight, the hole bridged over temporarily. The hole was cleaned-out to a depth of 10,528 ft., preparatory to setting a 7-in. O. D. liner. The liner hung up at a depth of 10,494 ft. and was cemented in place at both top and bottom of the string.

M. L. CASHION

entered the services of the Gulf Oil Corporation April 30, 1923, while still attending Rice Institute at Houston, Texas—He graduated from that school in 1926—Is now assistant superintendent of production in the Houston Production Division.

Following a rather tedious fishing operation occurring after the liner had been cemented, it appeared that the well would have to be abandoned as had so many previously in the same area. Realizing, however, that abandonment because of failure to control the salt water flow would virtually condemn the entire Lake Borgne prospect, as well as other areas in which similar flows are know to exist, it was finally decided to employ every known tool and procedure, sparing no necessary expense, in an effort to control the flow of salt water and permit drilling to continue.

Every Emergency Anticipated

In mapping the general plan of attack, the outstanding aim was to anticipate and provide for every conceivable emergency. In most instances, not one, but two or more means of accomplishing the same task were provided. Such elaborate precautions were warranted, not only because of the

Salt-Water Flow Need No Longer in Drilling Operations

Pressure-drilling equipment and chemical treatment of mud to prevent flocculation resulting from excess salt water are important factors in successful completion of deep test in Gulf Coast

unknown pressures and other factors involved but because too often in the past, the difference between success and failure in a difficult drilling job has been caused by "hoping" that a certain contingency might not materialize and thus being unprepared for its occurrence. In retrospect, now that the work has been completed successfully, there is not a single one of the many precautions adopted that would be eliminated in attacking another problem of the same type. Even though a few of the emergency features were not called into play on this particular well, there is no reason to believe that they might not be needed on the next job.

Although every item of equipment on the rig and every phase of the procedure contributed to the success attained, the points of outstanding interest were (1) the pressure drilling equipment and technique and (2) the mud treatment. It is noteworthy, however, that relatively few innovations in equipment or methods were required. That is to say, nearly all pieces of equipment employed have been used elsewhere. Success in the undertaking did depend, however, upon a thorough knowledge of all drilling equipment and methods available and of their applications and limitations, and upon the ability to assemble those items best adapted to the job at hand. This point is made because of the desire to point out to other engineers that success in overcoming drilling problems often is not so much a matter of developing entirely new methods and tools as it is of intelligently using practices already available.

General Plan of Procedure

As the fishing operation was being completed, plans were formulated for moving-in pressure drilling equipment and for revamping or adding to the auxiliary equipment needed.

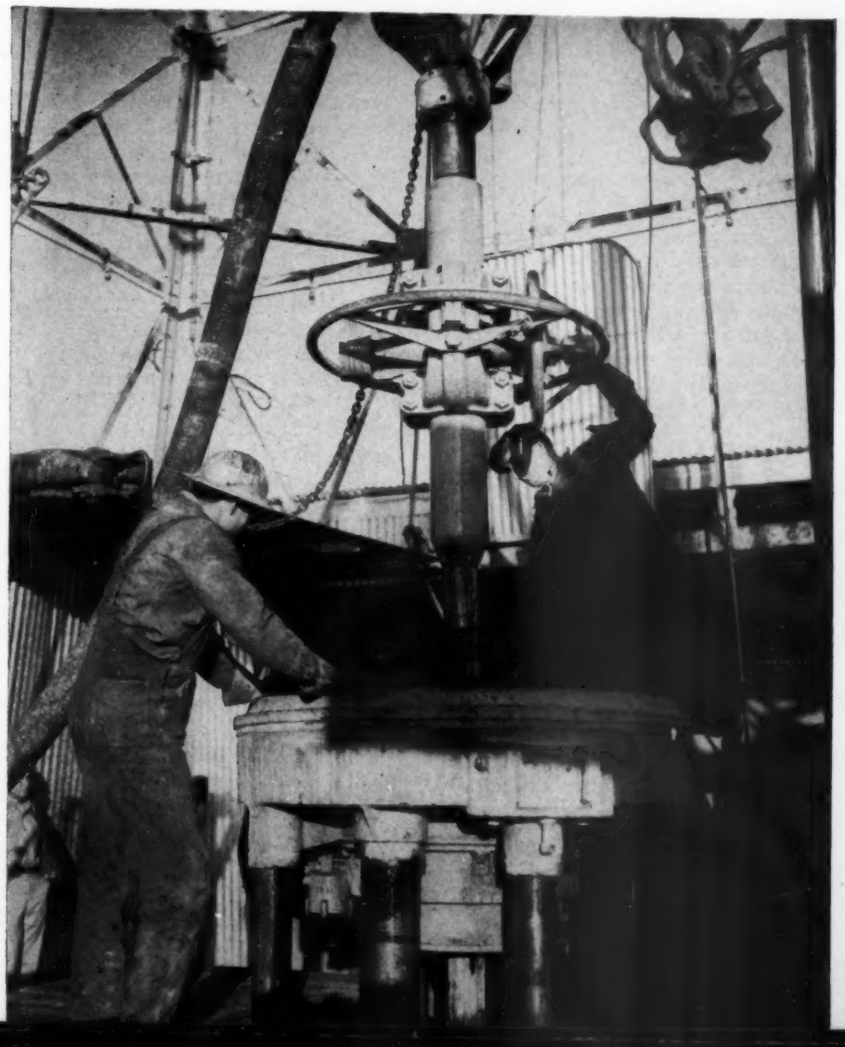
Previous experience with the salt water flows in wells drilled in St. Bernard Parish had demonstrated the inadequacy of normal water-mixed mud, even when heavily weighted, in resisting the high pressures of the salt water. Several contingencies might cause this salt water to enter the drilling hole. These include the swabbing action of the drill pipe as it is removed from the hole, insufficient mud weight, or inadequate knowledge of the pressures to be encountered. In the event that salt water should be mixed with the drilling mud, the colloidal portion thereof would be flocculated with the result that the flocculated drilling mud would deposit a much thicker filter cake, result in a much higher water loss from the mud, and thereby cause many attendant difficulties in drilling the hole.

The general plan, therefore, in preparing to drill ahead was to employ pressure drilling, in order to impose a back pressure on the return mud flow line and thus be prepared to resist effectively the ingress of salt water into the hole, regardless of how high the formation pressure might be. Equally important in the plan was the mud treatment adopted to prevent flocculation by such salt water as might be admitted into the hole.

Pressure Drilling Equipment

It is generally understood that the essential difference between pressure

Fig. 2. The hydraulic rotary table and special kelly cock are important items of the pressure-drilling equipment



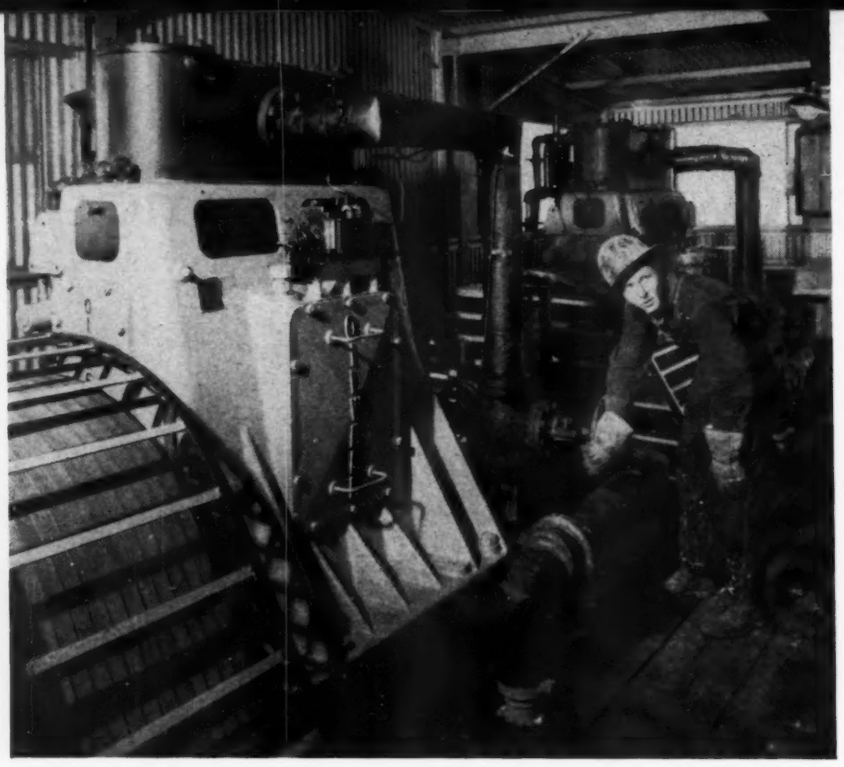


Fig. 3. This 10 by 9 steam engine drives the slush pump situated on the lower deck

drilling and ordinary drilling is in the ability to maintain back pressure on the mud circulatory system and thus be able to augment the hydrostatic pressure of the mud column. In ordinary drilling, the mud is returned to the surface directly into open pits and consequently no more than atmospheric pressure may be imposed. An increase in pump pressures and mud volumes only momentarily imposes additional pressures against the wall of the hole and is quickly translated into increased mud velocity only, inasmuch as the system is always discharging against no more than atmospheric pressure at the surface.

In pressure drilling, on the other hand, the mud discharge line or lines may be equipped with valves or chokes capable of being regulated to maintain any desired back pressure required to resist the abnormally high pressures of any formation that might be encountered. It is conceivable even that full pump pressure, plus of course the weight of the mud column but minus the pressure drop due to friction, might be imposed against the bottom of the hole by entirely closing the valves on the mud return line. This extreme use of pressure drilling would, of course, never be resorted to in practice because of the hazards accompanying the complete cessation of circulation. It does illustrate, however, the added flexibility of pressure control possible with pressure drilling as compared to normal drilling.

Inasmuch as pressure drilling requires that the mud circulatory system be essentially a closed system, it is necessary to provide a means of sealing-off the annulus between the drill pipe and casing in addition to installing valves or chokes on the mud return lines. Likewise, it is necessary to provide back pressure or check valves in the drill string itself to prevent mud being blown-out of the drill pipe when adding a joint or when making a trip.

The more important elements of the plan for installing pressure drilling equipment on Lake Borgne 4-RR State were as follows:

1. Hydraulic feed rotary (including snubbing equipment).
2. Pressure control equipment on the wellhead.
3. Chokes on the mud return lines.
4. Back-pressure valves, etc., in the drill string.
5. External-flush drill pipe (to permit going in and out of the hole through the drilling packer under pressure).

1. **Hydraulic feed rotary.** The hydraulic feed rotary was selected not only because advance of the drilling bit may be closely controlled but because it is adapted to the use of snubbing equipment so that the movement of the drill pipe upward or downward may be obtained independently of the drawworks by pressure exerted in hydraulic cylinders. A pressure of 800 lb. in the cylinders will exert a lift of 141 tons on the rotary.

The hydraulic rotary was installed on the drilling barge by means of a special cradle attached to the understructure and designed to support the total weight of the rotary and of the entire string of drill pipe.

A complete set of hydraulic snubbing equipment was installed, making it possible to snub the drill pipe in or out of the hole under high pressure. This snubbing equipment consisted of the following: (a) hydraulic snubbing cylinders actuated by a special hydraulic pump, (b) one snubbing yoke that grips the pipe and performs the actual snubbing operation, and (c) one set of double-acting automatic drill-pipe slips. These special slips are designed to grip the drill pipe and support its weight when a sufficient length of drill pipe is in the hole so that its total weight is greater than the pressure in the well. Conversely, these slips grip the pipe and prevent its upward movement when the pressure in the well is greater than the weight of the drill pipe. These slips also grip the round kelly used on the job, and serve as a drive bushing to rotate the drill pipe. A round kelly was selected because (1) the weight of the drill pipe is exerted in the rotary at all times but more important because (2) it was desirable to reduce to a minimum the amount of wear in the drilling packer while drilling under pressure.

Movement of the hydraulic rotary and snubbing equipment was controlled by valves in a manifold situated adjacent to the driller's stand at the drawworks.

2. **Pressure control equipment on the wellhead.** The pressure control hook-up consisted of one shutoff valve or master gate, two ram-type blowout preventers, and one automatic combination blowout preventer and drilling packer. Because space beneath the floor was limited, it was necessary to cut off the flanges normally used to bolt the valves together, and weld the bodies of the three blowout preventers in a single unit as shown in Fig. 1. This work was done in the shop prior to delivery, using a length of drill pipe through the three valves as the welding was started, to assure perfect alignment.

This control assembly also included (a) outlets to provide circulation through an ordinary flow line when no surface pressure was present, (b) outlets for return circulation through a choke system when surface pressures were being used, and (c) outlets for the purpose of maintaining constant pressure in the hole by pumping-in fluid to fill the space vacated by the drill pipe as it was withdrawn from the hole.

3. **Chokes on the mud return lines.** Three variable chokes and one fixed choke were used on the mud re-

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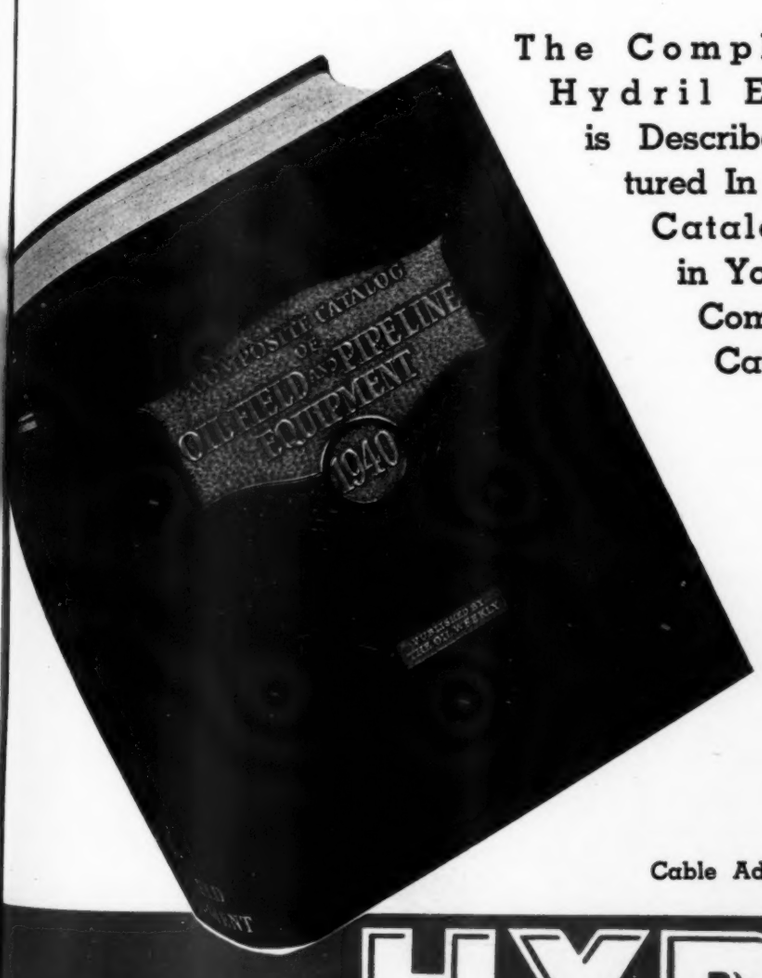

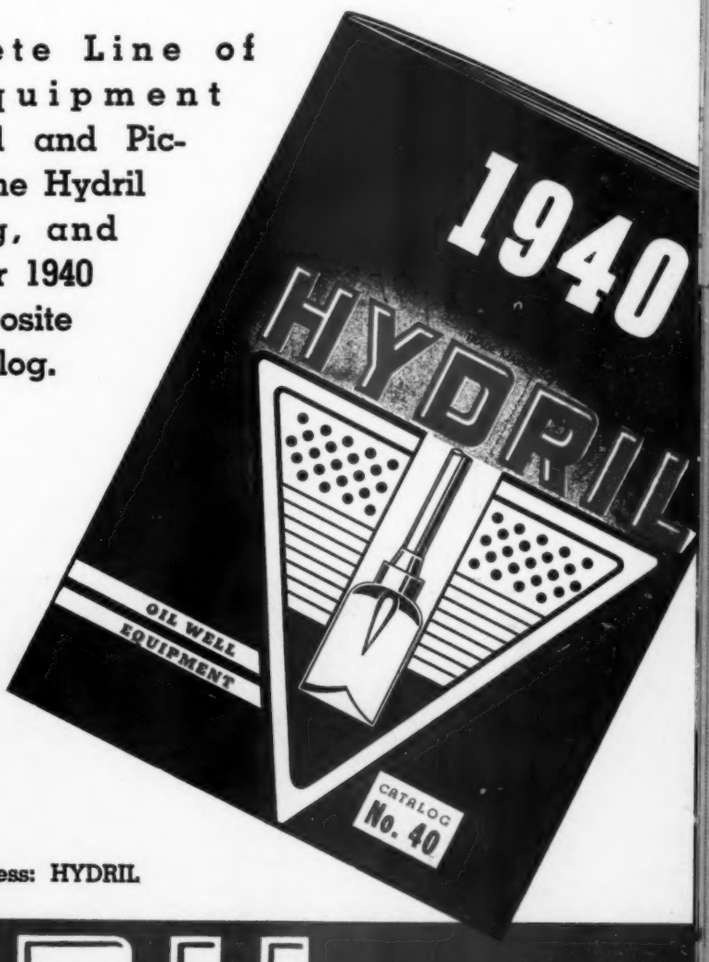

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turn manifold as shown in Fig. 4. The three 1½-in. and one 2-in. lines from the chokes discharged into two vibrating-screen shale shakers set over an enclosed mud ditch.

The mud return manifold was arranged so that returns could be taken from either of the flow outlets, above and below the master gate, already described. It was also possible to employ reverse circulation, should this prove desirable.

4. **Back-pressure valves in the drill string.** Ample provision for resisting upward flow of fluid through the drill pipe was obtained by the use of flapper-type back-pressure valves in the drill string. These back-pressure valves effectively prevented mud under pressure being blown from the drill pipe while joints were being added or round trips were being made.

Also provided as a precautionary measure was a drop-in type back-pressure valve to be used if the regular back-pressure valves should fail. Use of this drop-in valve requires that a special receiver sub be installed in the drill string at any desired point. In an emergency, the back-pressure valve may be lubricated through the special swivel goose-neck, after which it will settle until it lodges in the special sub and prevent the back flow of mud above that point. The drop-in type valve would serve also if a twist-off of the drill pipe had occurred below the receiver sub.

Another emergency feature was the special pump-down type twist-off back-pressure valve plug to be used in case the drill stem should part above the receiver sub. This plug can also be lubricated into the drill string through the swivel and pumped down until the point of the twist-off is reached, at which time it automatically sets itself inside the bore of a tool joint, thereby preventing back flow of the drilling fluid.

The kelly cock used on the well is believed to be an innovation. In order to obtain full opening through the valve and also to make certain that a positive shut-off could be relied upon, a high-pressure valve designed for other service entirely was built into the kelly to serve as a kelly cock. The accompanying photograph, Fig. 2, shows the valve assembly with the guard ring placed around it to protect it from damage.

Another device designed particularly for this job was the head assembly by which each stand of drill pipe could be filled with mud as it was attached. This practice was necessary because the back-pressure valves in the drill string prevented the additional stands being filled through the bit. The filling head incorporated a release valve through which the displaced air from the drill pipe might escape.

5. **External flush drill pipe.** External flush, internal upset drill pipe was used so it could be run in and out of the hole through the drilling packer head under pressure. Even the drill collar assembly of two 30 ft. 4⅝-in. O. D. by 2¼-in. I. D. drill collars was connected by external flush type threads so that the entire string could be snubbed in and out of the hole under pressure.

Special Drilling Mud

In order to prevent the flocculation of drilling fluid previously mentioned, it was decided to use silicate of soda as one of the ingredients of the mud. Used elsewhere frequently as a means of combating heaving shale, it is believed that this is the first time silicate of soda has been used to counteract the effect of high-pressure salt water flows.

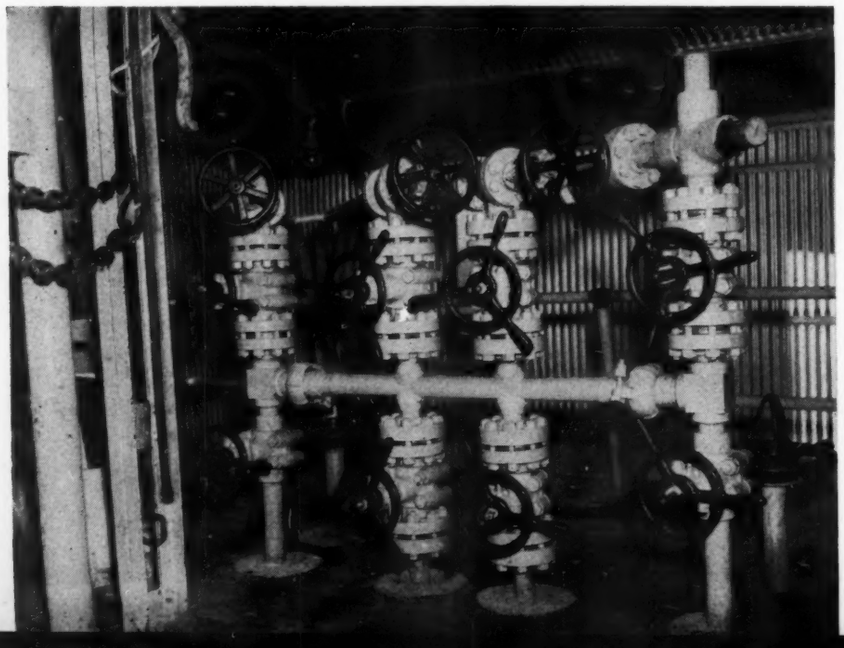
The control of high-pressure salt water is quite a different problem from the control of heaving shale, but the properties of an ideal drilling mud for controlling each, it is believed, would be quite similar. Hydrous disintegration of shale may or may not be a factor associated with the control of high-pressure salt water, depending upon the type of formation exposed in the open hole above and below the salt water sand section. Numerous cases have been reported where sloughing of shale into the hole gave serious trouble while attempting to control a salt water flow. Such cases of sloughing shale trouble are probably prompted by the adverse effect of salt water upon the mud and the shale walls of the hole. It does appear that a mud that protects the open hole by preventing hydrous disintegration of the shale exposed offers a tremendous advantage if not considered an absolute necessity.

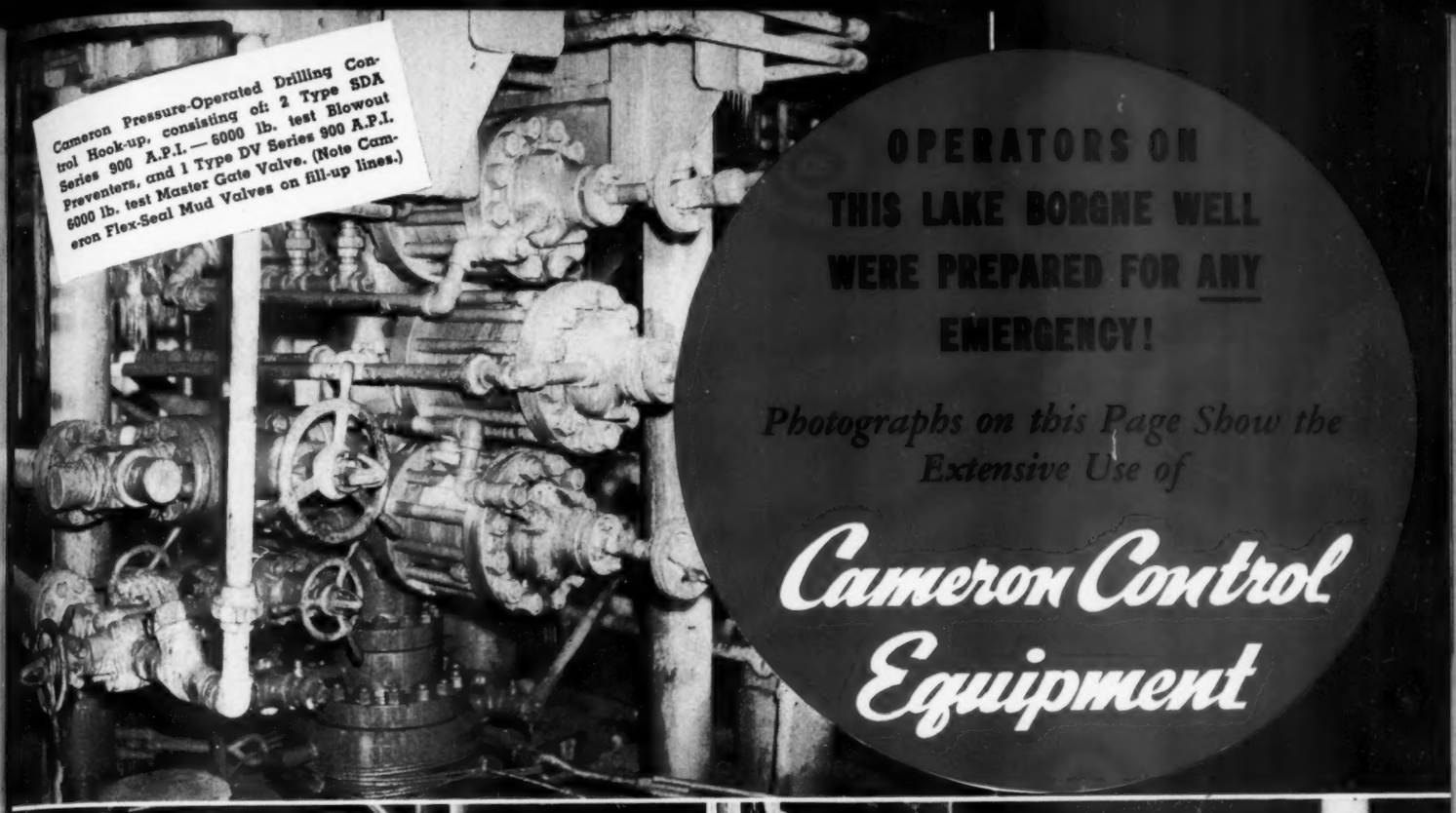
High mud weights are needed to balance the abnormally high formation pressures associated with the salt water problem. Silicate mud is particularly well suited in this respect, in that the liquid phase weighs 11.8 lb. per gal. compared to 8.33 lb. per gal. in the case of ordinary water muds. The extra weight in the liquid phase of silicate mud allows the fabrication of high-weight muds with a much lower suspended-solids content. In other words, a 16 lb. per gal. silicate mud has a suspended-solids content somewhat less than that of an ordinary 13 lb. per gal. mud. The control of the viscosity, gel strength, and other properties of a mud are increasingly complicated and difficult as the suspended-solids content of a mud increases.

Quite generally, abnormally high formation temperatures are found associated with these high salt-water pressures. The bottom-hole mud temperature in the Lake Borgne well showed to be 285°F. when measured at 10,640 ft. Such high temperatures have an adverse effect upon ordinary highly weighted muds, causing thickening and other changes. Silicate mud seems to be very resistant to the effect of high temperatures. Returns of silicate mud from the bottom of the hole following a trip did not show gelation or thickening.

Probably the most troublesome factor associated with the control of high-pressure salt water is the resulting contamination of the drilling mud. A

Fig. 4. The mud return manifold with its variable and fixed chokes provided extreme flexibility in controlling the mud flow



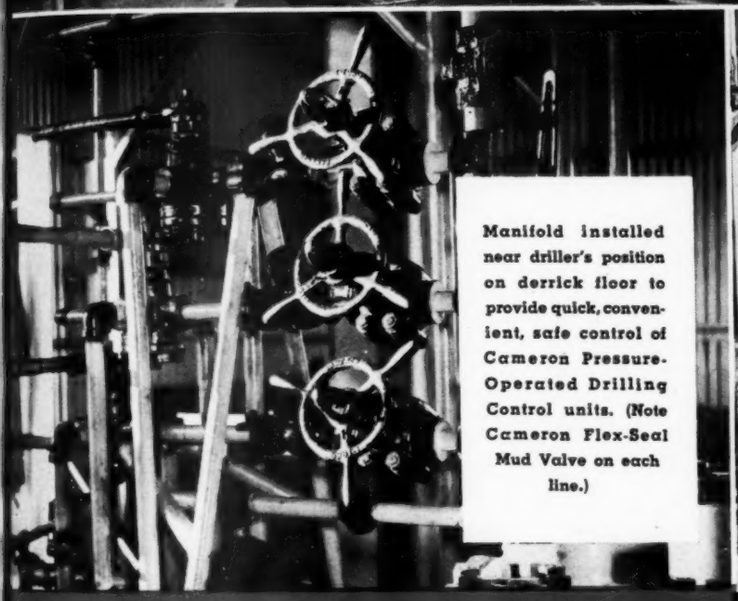


Cameron Pressure-Operated Drilling Control Hook-up, consisting of: 2 Type SDA Series 900 A.P.I. — 6000 lb. test Blowout Preventers, and 1 Type DV Series 900 A.P.I. 6000 lb. test Master Gate Valve. (Note Cameron Flex-Seal Mud Valves on fill-up lines.)

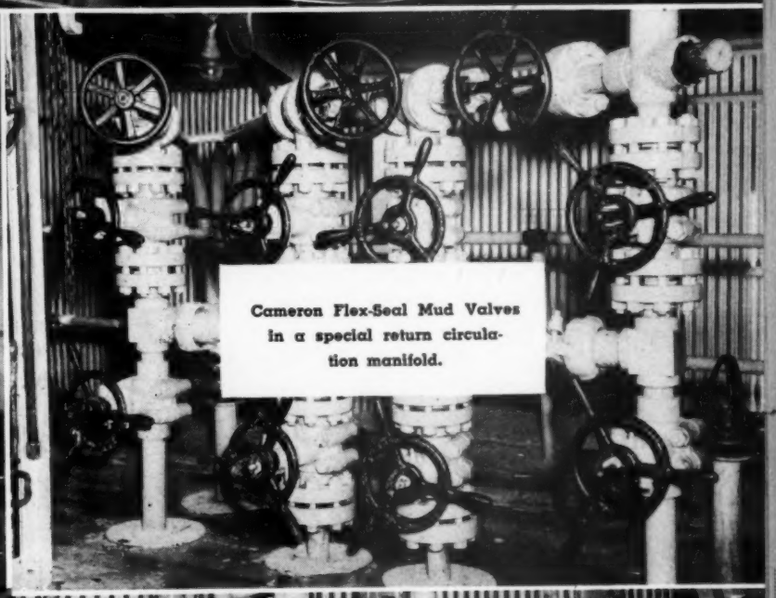
OPERATORS ON THIS LAKE BORGNE WELL WERE PREPARED FOR ANY EMERGENCY!

Photographs on this Page Show the Extensive Use of

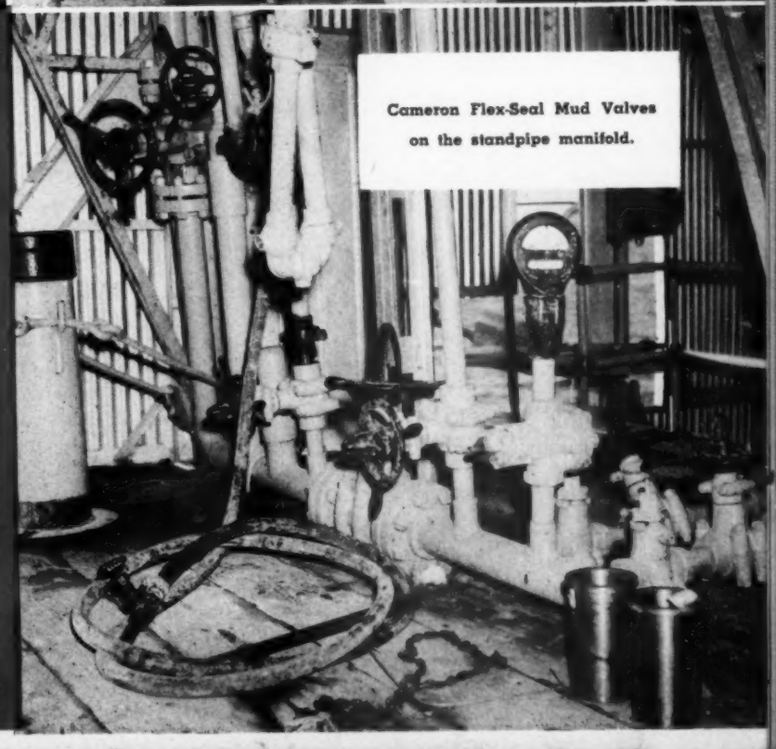
Cameron Control Equipment



Manifold installed near driller's position on derrick floor to provide quick, convenient, safe control of Cameron Pressure-Operated Drilling Control units. (Note Cameron Flex-Seal Mud Valve on each line.)



Cameron Flex-Seal Mud Valves in a special return circulation manifold.



Cameron Flex-Seal Mud Valves on the standpipe manifold.

The recent successful drilling of a test well in Lake Borgne, St. Bernard Parish, Louisiana, to a depth of 12,019 feet marks an important advancement in the technique of pressure drilling. (See article beginning on page 90.)

The use of Cameron Type SDA Pressure-Operated Blowout Preventers, a Type DV Pressure-Operated Master Gate Valve, and numerous Cameron Flex-Seal Mud Valves for this unusual drilling assignment provides additional proof of the confidence placed in Cameron equipment by men responsible for the safe drilling and completion of wells in both wildcat and proven high pressure areas.

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small amount of salt water will flocculate and thicken an ordinary highly weighted mud rendering it difficult if not impossible to control. It is this very sudden thickening and other changes of the ordinary mud due to salt-water flocculation that has caused serious trouble in numerous cases. Silicate mud in not affected by such contamination from salt water and the properties may be adjusted as needed to control the pressure encountered.

The silicate of soda base mud has for its fluid phase one-third by volume saturated sodium chloride (common salt solution) and two-thirds by volume of a special silicate of soda preparation. This mixture of solutions was substituted for the water in ordinary drilling mud. To this solution was added about one lb. per gal. of good colloidal clay, such as bentonite.

At the beginning of the operation the silicate mud was weighted-up to 15.6 lb. per gal. After drilling to 10,638 ft., which was below the section that previously gave trouble, the well was tested and it flowed against the column of 15.6 lb. per gal. mud. The mud weight was then increased to 16 lb. per gal., which was just sufficient to balance the salt-water pressure, and drilling under pressure proceeded. During the rest of the operation the mud weight was maintained at about 16 lb. per gal. and back pressure was maintained on the mud column to provide a factor of safety.

During the drilling from 10,494 to 12,019 ft., the silicate mud behaved very much as expected. Upon several occasions small amounts of salt water from the formation flowed into the mud column, but returns showed very little change in the mud other than a slight thinning and a decrease in the silicate and salt concentration in the liquid phase. The control of the viscosity was much less of a problem than normally would be expected of a 16 lb. per gal. mud. The gel strength of the mud was maintained at a low value during the entire operation to minimize any swabbing effect on trips and to facilitate the removal of gas had it been encountered. The hole showed no signs of sloughing and remained in good condition during the entire operation.

Both silicate of soda and sodium chloride are very strong flocculating agents and, in addition to this, the silicate of soda has a sealing action upon the shale and shaly sand, which greatly reduced the infiltration of water. The silicate of soda mud, having been completely flocculated at the time of mixing, will be unaffected by further additions of salt, such as from an inflow of salt water.

Pressure Drilling Procedure

After installation of the above described equipment had been completed, pressure drilling was begun, first by circulating the special mud and imposing the required back pressure on the circulatory system necessary to offset the pressure of the salt water formation. It was found that a back pressure of about 250 lb. was sufficient to prevent ingress of salt water during normal drilling. When coming out of the hole, however, the back pressure was increased to 750 lb. to compensate for the reduced friction loss during the operation.

Pump pressures varied during the operation from 1250 to 2000 lb., reaching a maximum of 2700 lb. only occasionally.

Some may wonder why the particular combination of 16-lb. mud and 250-lb. back pressure was used instead of, for example, increasing the mud weight sufficiently to provide all the pressure required. The reason for this is twofold: (a) the potential difficulties of controlling mud properties increase rapidly as mud becomes heavier, as is generally known, but more important is (b) the ability to obtain almost instantaneously any desired increase of pressure when back pressure may be imposed; an increase that can be obtained only after several hours of conditioning, usually, when mud must be further weighted. As the second of these reasons is important enough when confronted with uncertainties as in the 4-RR State well to warrant installation of pressure drilling equipment, it is obvious that a combination of mud weight and back pressure should be used to best advantage.

During pressure drilling, the drilling packer was kept closed at all times on the round kelly and on the flush-joint drill pipe as round trips were made. The ram-type blowout preventers were kept open and were used only as auxiliary control valves in case repairs were necessary to the drilling packer.

The predetermined surface pressure on the mud lines was maintained accurately by means of a special pump equipped with a steam-regulating valve; this pump automatically injected fluid to replace the drill stem as it was pulled out of the hole.

When round trips were made under pressure, it was necessary to snub-out the drill pipe to prevent its being blown out of the hole, until the bit was above the master gate. The master gate would then be closed, the drilling packer opened, and the bit removed from the hole. After the bit was replaced, it would be run through the drilling packer, the snubbing equipment attached, and the master gate opened. The drill pipe would then be snubbed or forced into the hole against pressure until enough pipe was in the hole to allow it to fall under its own weight.

Inasmuch as the pressure drilling was done using a 6-in. bit, the drilling fluid volumes required were not large. This explains the ability to use only one of the four flow lines during most of the drilling, with only a 9/16-in. opening in the choke.

Drilling substantially in the manner described, the 6-in. hole was deepened from the liner seat at a depth of 10,494 ft. to the total depth of 12,019 ft., thus attaining the desired depth of 12,000 ft. initially set as a goal. The fact that the well was not completed as a producer is not so important in this instance, because of the development of a technique whereby high-pressure salt water flows may be controlled. This procedure should enable many other wells to be drilled and completed as producers that otherwise would have to be abandoned, and thus the costs of developing this method should be returned manyfold in the future.

Other Equipment on the Drilling Rig

Although not new on drilling rigs owned by the Gulf Oil Corporation, the efficient steam equipment used in drilling Lake Borgne 4-RR State played an important part in the overall economy of operation and successful application of the pressure-drilling technique. The general arrangement of the equipment has been described previously[1] so that only the more important points will be reviewed here together with mention of one or two new additions to the equipment.

Four vertical twin-cylinder steam engines were employed to supply power as follows:

(a) a 12 by 12 engine driving the drawworks,

(b) a 7¾ by 7 engine driving the rotary table independently of the drawworks, and

(c) two 10 by 9 engines, each driving a 7¼ by 18 power slush pump.

[1] "A Modern Steam Rig That Approaches Power Plant Efficiency," by M. L. Cashion, *The Petroleum Engineer*, September, 1937.

All engines were mounted on the derrick floor; the two engines driving the pumps were connected by V-belt drive to the pumps on the deck below.

Economy of steam consumption was attained in these steam engines by use of a hand-adjustable cutoff control, so that full advantage of the expansive force of the stream may be obtained.

In addition to the four engines listed above, a direct-acting auxiliary steam pump was installed to increase the normal 300-lb. pressure available on the water line to the derrick floor, to 2500 lb. in the event the higher pressure would be needed to operate the hydraulic rotary, snubbing equipment, etc.

Two 125-hp. boilers generating steam at 350-lb. pressure supplied the entire power requirements on the rig. Steam from the engines was exhausted into a surface condenser and returned to the boilers, thus obtaining the economy in water consumption so important in marine drilling operations where water must be barged-in from shore.

Make-up water is added to the hot-water tank as needed by one of two 10 by 4½ by 10 feedwater pumps from the water storage tanks. The other pump is equipped with an automatic steam throttle so that 300-lb. pressure on the water line to the floor is instantly available when the driller opens one of the water valves.

Full advantage of the efficiency that results from adequate preheating of the feedwater is obtained by the use of a preheater, to which incoming water is pumped prior to entering a combination feedwater heater-pump unit. Known as the open-type heater, the incoming feedwater is sprayed through a springloaded valve, and comes into direct contact with exhaust steam at a pressure of approximately 10 lb. per sq. in. Thus, the feedwater is subjected to two separate preheatings to attain a water temperature of about 210°F. into the boilers.

The boilers were fired with oil, using the comparatively new forced-draft burners, in which the oil is mechanically atomized and draft is provided by a fan, driven by a small steam turbine. Experience with these burners thus far indicates they are an important factor in attaining even greater heat economies. Inasmuch as no steam jets are required in the stacks to induce draft, and the steam ordinarily used to atomize the fuel oil is eliminated by mechanical atomization, the saving in steam is considerable.

A separately fired superheater was employed to obtain steam at a temperature of 550°F., representing a superheat of 115°F. at 350-lb. pressure.

The use of sulphuric acid in the feedwater was an innovation in water treating not generally used in oilfield boilers although it is used extensively in large power plants. The water barged-in for boiler purposes contained 42 grains of chlorides and 21 grains of sodium bicarbonate per gal. Treatment with sulphuric acid eliminated virtually all foaming and sealing, and resulted in practically trouble-free operation. On occasions, having this acid treatment available, feedwater was taken directly from the lake. The amount of acid added was varied depending upon the composition of the water.

Another feature believed to be new on drilling rigs was the installation of a belt conveyor to move mud, cement, and other sacked material from the barge-side into the rig.

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New Plant Indicates Recycling Not Limited to Large Properties

Distillate separation based on low-pressure equilibrium principle proves efficient in small-capacity Cayuga, Texas, installation

RAY C. FISH

has occupied the position of sales engineer with the Stearns-Roger Manufacturing Company, Denver, Colorado, for the last ten years.

By
RAY C. FISH
Sales Engineer, The Stearns-Roger Manufacturing Company

ROESER and Pendleton's recently completed plant in the Cayuga field, Anderson County, Texas, demonstrates the feasibility of operating relatively small holdings for the recovery of distillate under pressure maintenance.

The installation, although small, is complete in all respects. It includes facilities for returning the residue gas to the producing formation, recovery of condensate from the gas, and stabilization of the condensate to desired vapor pressure.

Particular attention was paid to the arrangement of the plant equipment. This, plus the use throughout the plant of the latest control equipment, requires a minimum of operating labor. At the present time, the plant is being operated by one operator per shift.

The gas-handling capacity of the plant was designed for 10,000,000 cu. ft. per day at a plant intake pressure ranging from 1000 lb. to 1200 lb., and a formation injection pressure of 1600 lb. Distillate is recovered from the gas by low-temperature equilibrium separation. The distillate recovery and stabilization part of the plant was designed for a capacity of 200 bbl. per day.

The flow sheet that accompanies this article will be used as the basis for explaining the details of design and operation.

The wet gas entering the plant from the various producing wells passes first through an inlet scrubber for removal of any discolored condensate and water. From the scrubber the flow is through an atmospheric cooling section situated in the base of the cooling tower. Here the temperature is lowered from about 110°F. to 90°F., depending on atmospheric conditions.

Compact compressor building made possible by use of angle-type compressors

Gas leaving the cooler passes upflow through two shell-and-tube type gas-to-gas heat exchangers. Here the temperature is further reduced by exchange with cold residue gas. The gas flow from the exchangers is then through the ammonia chiller to the gas-distillate separator. A control valve is installed in the piping between the chiller and separator for maintaining constant separator pressure and taking maximum advantage of any cooling by expansion.

The operating temperature of the separator is held to a minimum of 0°F. by balancing the gas compression and refrigeration load of the compressor unit.

The flow of the residue gas from the separator is then through the two gas-to-gas exchanger units, counter-

flow to the wet gas, directly to the suction of the gas compressor cylinder.

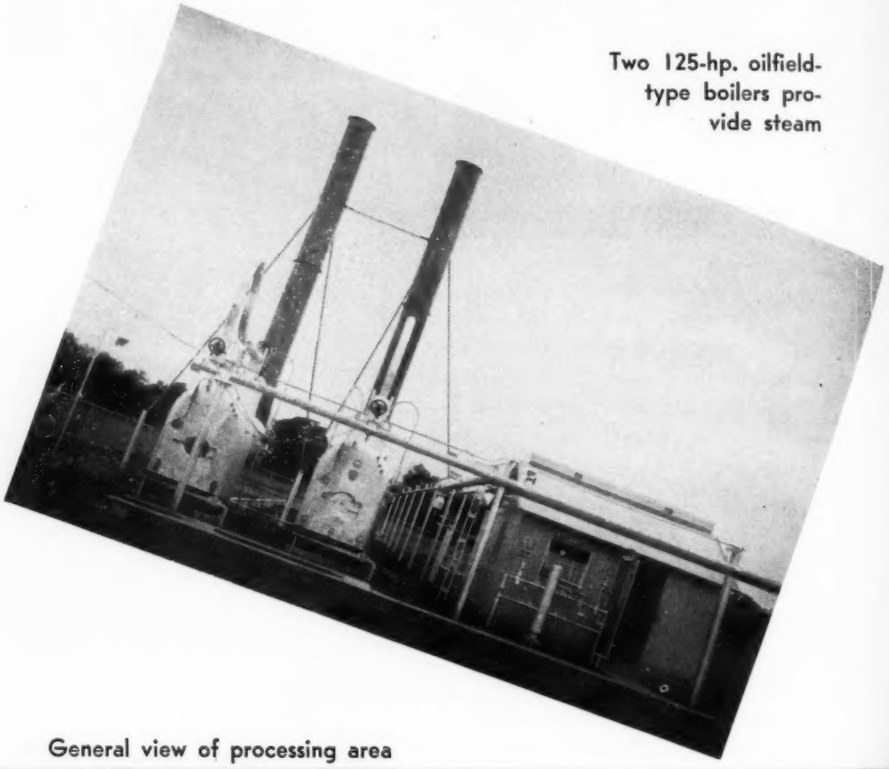
Refrigeration of the wet gas in the chiller is accomplished by a two-stage ammonia refrigeration cycle. The gas tubes of the chiller are kept completely immersed in boiling ammonia, the level in the chiller being maintained by a liquid-level controller.

The compressor unit performing both the gas compression and ammonia refrigeration duties, is an angle type, 400-hp. unit, having four power cylinders and three compressor cylinders.

Compression of the residue gas is by one 5½-in. diameter, double-acting, cast-steel cylinder. The other two cylinders serve the refrigeration cycle. The low-pressure ammonia cylinder is 17-in. diameter, single-acting, and the high-pressure cylinder is 11-in. diameter single-acting. Both ammonia cylinders are equipped with variable clearance pockets. The gas compressor cylinder is equipped with adjustable clearance plugs. This permits balancing the horsepower between the two different duties and keeping the unit fully loaded over the range of operating conditions.

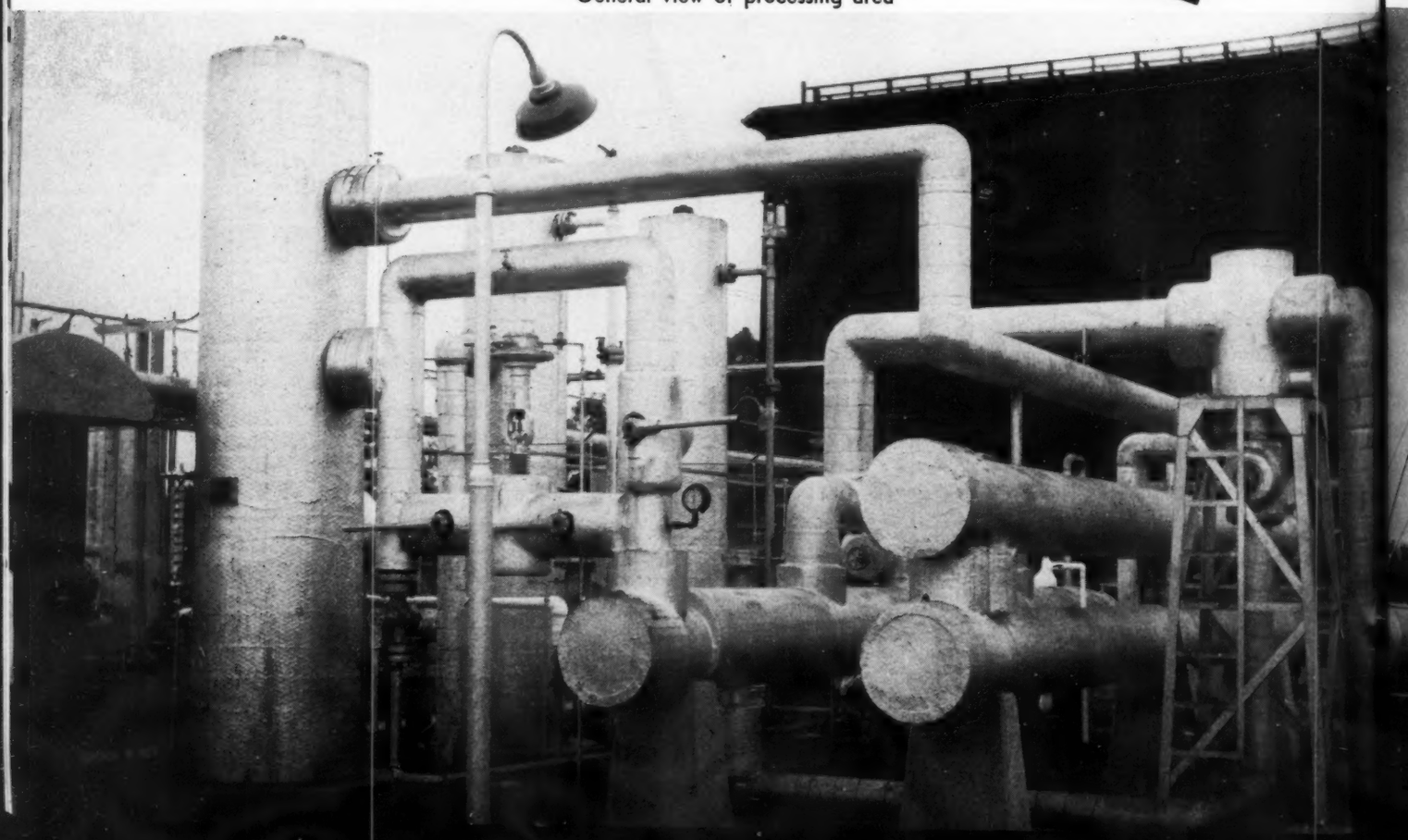
The distillate separated from the gas in the gas-distillate separator is passed through three stages of weathering for rejection of methane and ethane to a point where reflux can be produced for the stabilizer. The stage-weathered distillate is pumped from the low-pressure combination brine settling and surge tank through G-fin type exchangers to the stabilizer column, which is 24-in. O.D. and 54 ft. 6 in. high. The stabilized distillate is withdrawn from the stabilizer reboiler as an 18-lb. Reid vapor pressure product, passes through the G-fin exchangers, counterflow to the cold weathered distillate, to storage. Tankage consists of two 10-ft. 6-in. by 40-ft. horizontal vessels each having a capacity of 26,612 gal.

Vapors from the top of the stabilizer, at a temperature of 140°F., are passed through cooling coils in the



Two 125-hp. oilfield-type boilers provide steam

General view of processing area

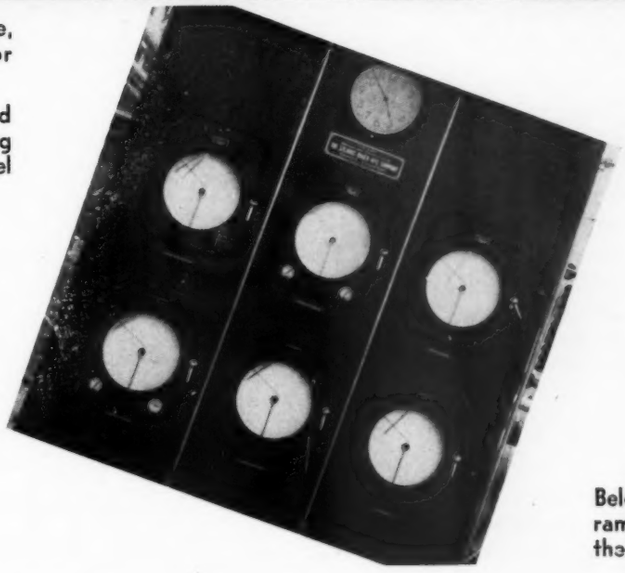


cooling tower, and the condensate is returned to the reflux accumulator, thence back to the stabilizer. This process is repeated until all usable fractions are recovered from the vapors.

Hydrate formation in the exchangers, chillers, and separators, is prevented by injection of calcium chloride brine into the gas stream just ahead of the gas-to-gas exchangers. The brine is carried along by the velocity of the gas through the exchangers and chiller to the gas-distillate separator. It is removed from this tank along with the distillate passing through the various flash tanks to the combination brine settling and stabilizer surge tank. An interface level controller removes the brine from this tank directly to the evaporator unit where it is concentrated and stored, ready for recirculation.

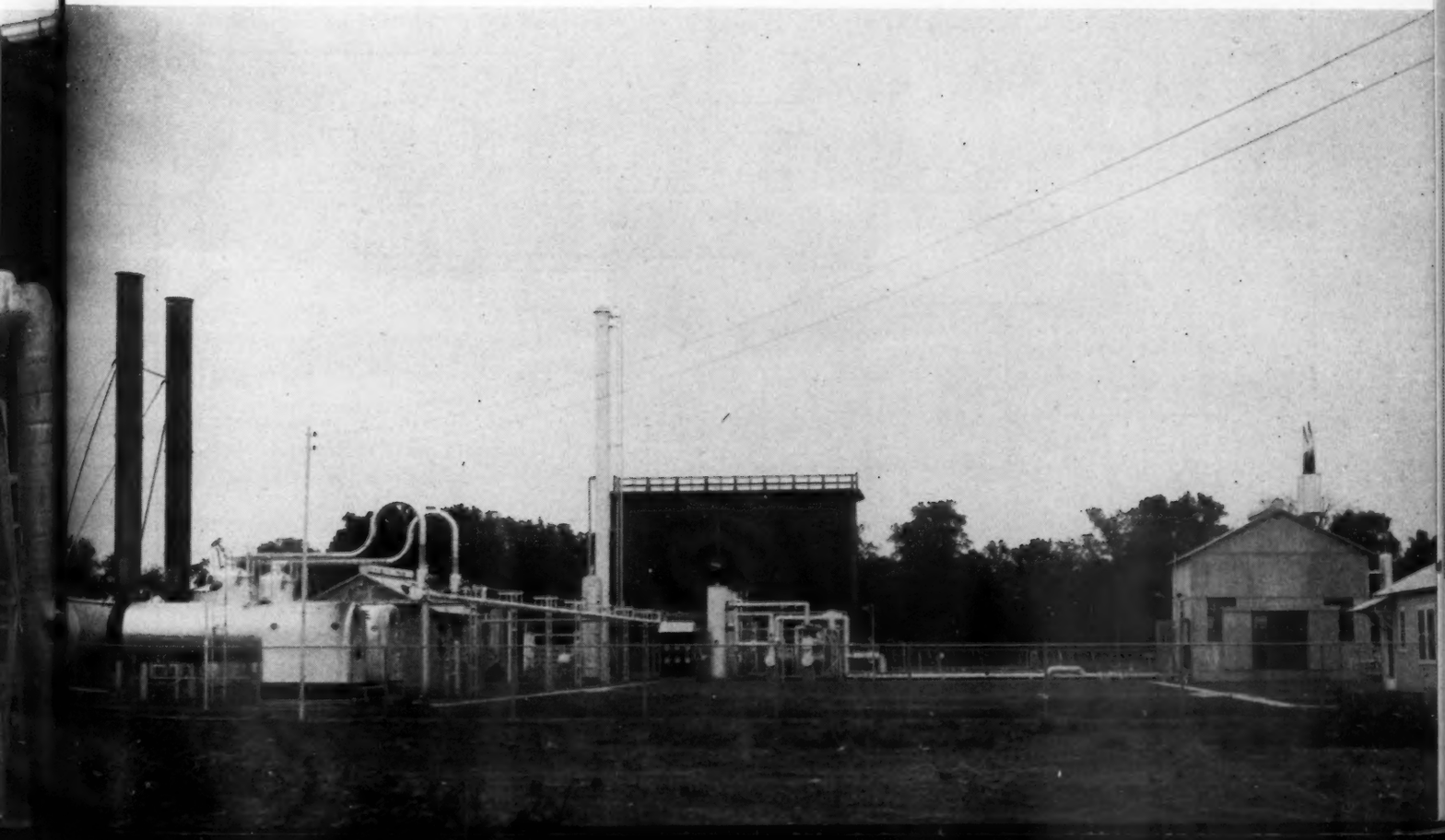
Two oilfield type, 125-hp. each, 250-lb. working pressure boilers were installed to supply steam for the operation of the stabilizer unit and the various pumping duties. The operation of these boilers is entirely automatic, water level being controlled by water level controllers and steam pressure by boiler fuel governor. One boiler will carry the entire plant load when operated at 175 percent of normal rating, thus permitting one to be shut down

Above—Angle-type, 400-hp. compressor unit



Right—Control and and recording panel

Below—Panoramic view of the plant



when necessary for cleaning or other maintenance.

The cooling tower is an 8-bay induced down-draft tower. The structure is 22 ft. wide by 48 ft. long by 36 ft. high, constructed of California redwood.

The power and compressor cylinders of the gas compressor units are cooled by a closed jacket-water system. The warm jacket water from the unit enters a vertical tank from which it is circulated by a centrifugal pump through a cooling section situated in the base of the cooling tower.

The jacket-water pump is part of a tandem turbine-driven pump set that also circulates water over the cooling tower. A spare pump set is provided.

Electricity for plant and camp lighting is supplied by a turbine-driven, a-c. generator set. The air-starting unit is a two-stage, air-cooled compressor unit V-belt driven by a 4-cylinder, air-cooled engine, suitable for 250-lb. operation.

The gas compressor unit is housed in a 24-ft. square steel building. The air-starting unit, electric generator set, and boiler feed pumps are also housed in a steel building. The rest of the equipment, including the boilers and various pumps, are installed in the open. A building housing the office, laboratory, and small parts storeroom has been provided.

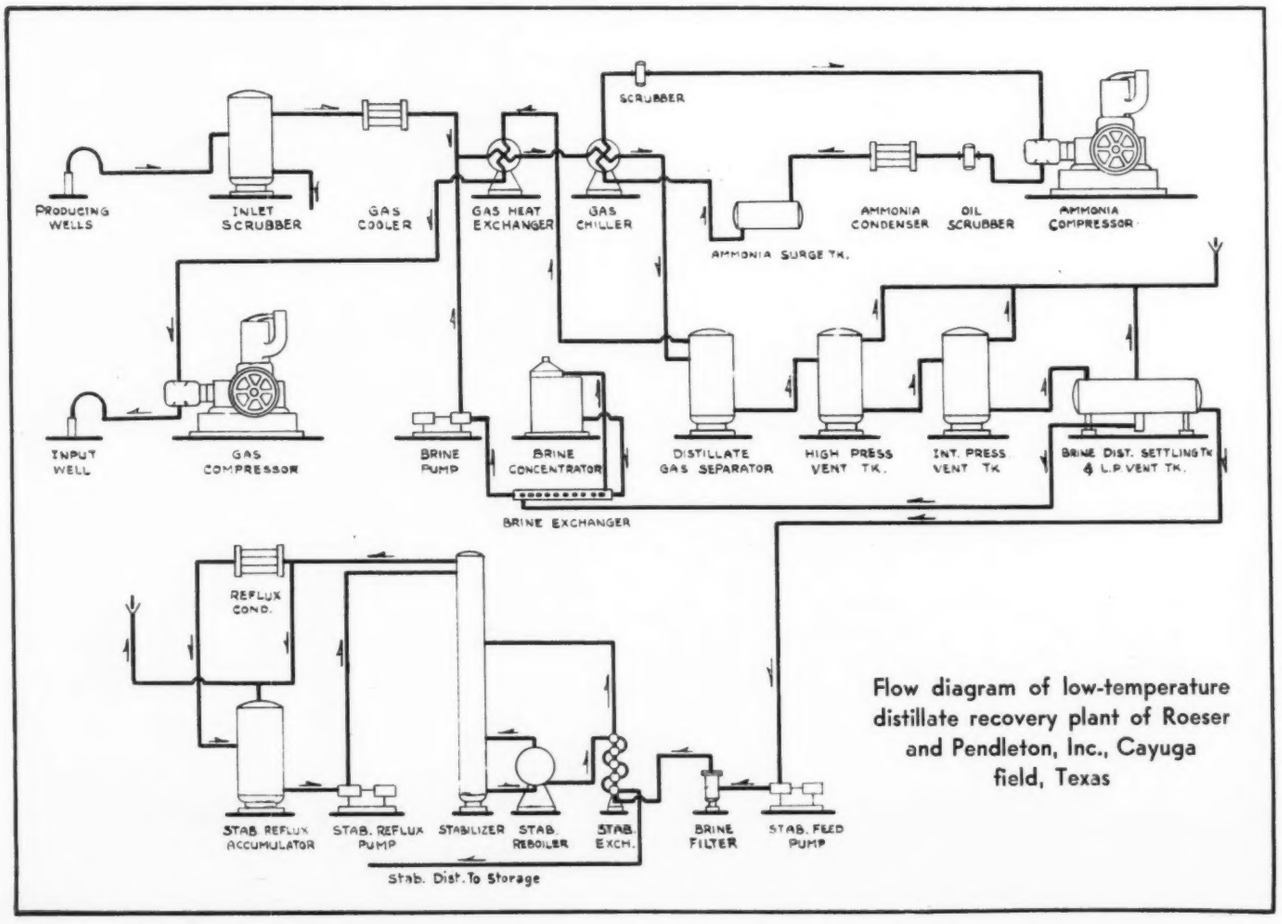
An emergency shut-down system is provided, several stations being installed at strategic locations throughout the plant. Turning the lever of a single valve at any one of these stations simultaneously shuts off the main gas supply entering the plant, vents the gas from the entire plant system, shuts down the compressor unit, cuts off the boiler fuel, and releases steam into the boiler fireboxes.

Four wells supply gas to the plant. One well is producing from the Trinity formation at a depth of 7640 ft., the other three from the Boyer sand of the Woodbine series at 4100-ft. depth. Bottom-hole pressure on the Trinity well is 2800 lb. per sq. in., which is reduced at the well by a choke to a pressure of 1450 lb., and further reduced to 1000 lb. by a field separator immediately before entering the plant. The Woodbine wells have a bottom-hole pressure of 1450 lb. The pressure of one well is reduced in two stages, at the well by a choke and by a field separator. The pressures of the other two wells are reduced only by field separators. All separators are on the plant intake, reducing to 1000 lb. per sq. in.

Use of separators was found necessary due to the fact that the Woodbine wells are low on the structure, near the oil sand, causing some oil to be produced with the gas.

The plant was put into operation early in May and has operated continuously since then at a capacity of approximately 10,000,000 cu. ft. per day and a production of approximately 200 bbl.

The plant was engineered, designed, and constructed by The Stearns-Roger Manufacturing Company of Denver, Colorado, and their associates, Parkhill-Wade, Inc., of Los Angeles, California.



Flow diagram of low-temperature distillate recovery plant of Roeser and Pendleton, Inc., Cayuga field, Texas

Distillate Recovery-Recycling Plants

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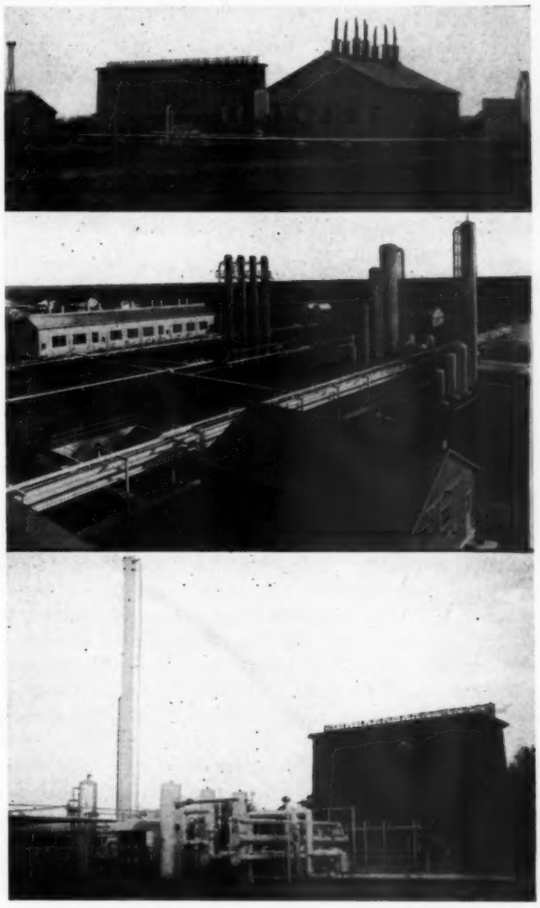
We have handled all phases of the three presently-known types of plants now processing gas for the recovery of distillate with pressure maintenance; i. e.,—

1. **Recovery through low temperature, using Regenerative Cooling Cycle.**
   Example: In Corpus Christi area, Texas —
   Initial capacity: 55 million cu. ft. of gas per day.
   Separation Pressure: 1,200 lbs.
   Input Pressure: 2,800 lbs.
   Production: 51,000 gals. per day of stabilized distillate.

2. **Recovery by high pressure Absorption Process.**
   Example: In Corpus Christi area, Texas —
   Largest high pressure Absorption Plant—Capacity: 128 million cu. ft. of gas per day (designed for ultimate capacity of 140 million cu. ft.).
   Absorber Operating Pressure: Up to 1,500 lbs. per sq. in.
   Compressors operating at 1,350 lbs. suction, 2,000 lbs. to 2,200 lbs. discharge.
   Production: 105,000 gals. per day motor gasoline, 6,000 gals. per day of kerosene.
   (Another plant just completed, in Corpus Christi area—same operating conditions, but two-thirds the capacity.)

3. **Recovery through low temperature, using Mechanical Refrigeration.**
   Example: In Cayuga Field, Texas —
   Capacity: 11,800,000 cu. ft. of gas per day.
   Separation Pressure: 1,200 lbs.
   Input Pressurt: 1,600 lbs.
   Production: 6,500 gals. per day of stabilized distillate.



The above projects were handled in our usual complete manner—the final step being testing and starting the plant, delivering it to our customer as a complete unit operating at proper efficiency.

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- ***Compressor Stations***
- ***Natural Gasoline Plants***
- ***Stabilization Plants***

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Proper Sealing of Abandoned Wells Important in Mining Areas

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

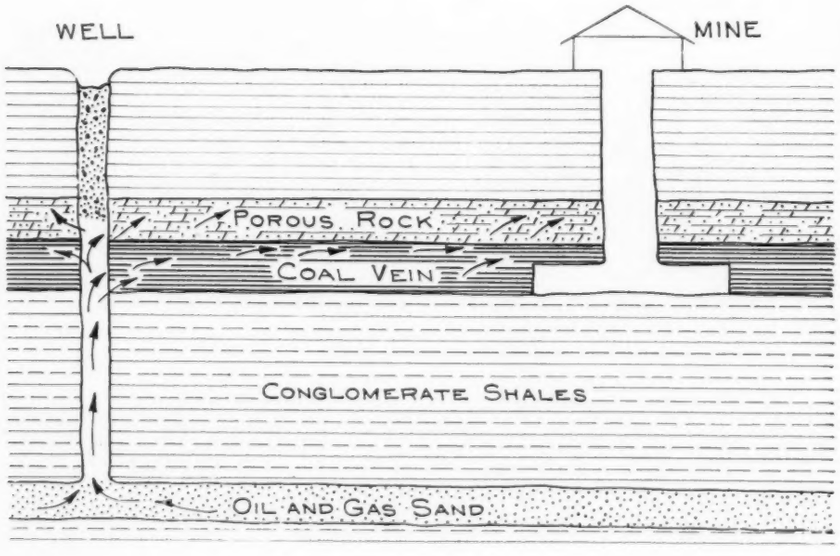
Various methods properly applied are found to result in effective shutoff of gas

By F. R. COZZENS
Equity Oil and Gas Company

THROUGHOUT the Allegheny coal regions there is a persistent belief that natural gas is a contributing factor in many mine fires and explosions. In the Willow Grove mine disaster of March 16, 1940, near St. Clairsville, Ohio, which cost the lives of 70 men, it was widely rumored that escaping gas from an abandoned well in that vicinity had filtered into the workings and been ignited from a friction spark or a miner's lamp. This rumor in the Willow Grove case, as in previous ones, was not borne out by thorough investigations by mining officials, but nevertheless, there are possibilities that can neither be disputed nor denied. We know that natural gas can, and often does, penetrate coal seams and other porous formations in the upper earth. We know also that natural gas can easily reach these upper formations from an improperly sealed oil or gas sand. As mine blasts are occurring with greater frequency in localities previously drilled for oil or gas, it appears probable that forthcoming revision of mining laws will require more rigid methods of sealing abandoned wells. Operators will be impressed with the fact that a sand is sealed not solely to exclude outside interference, but also to prevent elements within the sand-body from doing damage outside its scope. Fortunately, both effects may be obtained by the same operation.

Present state mining laws differ as to requirements for sealing abandoned wells. The device generally used in the eastern stripper oil fields is a tapered plug of wood, driven into the sand, and backed-up with cement slurry. This method is quite effective in closing the opening into the sand, provided enough loose material falls in on top to close cavities that form in the walls as the casing is lifted. Too often, however, the casing is lifted over the cement without providing loose filler. Chunks, boulders, etc., are allowed to drop into the hole in the wake of the casing, bridging it temporarily, but leaving long stretches of side-wall exposed. Over a course of years, gas pressure becomes sufficient to force openings around the weakened cement seal, and there is little or no barrier to

(Continued on Page 107)



Sketch depicting means by which gas from an abandoned well may travel to a mine shaft

F. R. COZZENS

was born near Marietta, Ohio, October 10, 1895 — Has served in the capacities of tool dresser, rig-man, foreman, scout, and lease hound—In 1929 he helped organize the now defunct Ohio-Pennsylvania Oil Company—Two years later he became connected with Lakeshore Oil and Gas Company, and when it merged in 1935 with the Equity Oil and Gas Company he was transferred to the latter as field man, the position he now holds — Has also performed some geological work in conjunction with the State Bureau of Mines.

(Continued from Page 104)

prevent its reaching any formation in the upper part of the abandoned hole. Closing the hole at the surface tends only to increase the gas pressure below ground. In outlying districts, casing-pulling crews, unless carefully supervised, are sometimes inclined to wink at technical rules of sand sealing. It is argued by many of these crews, and even by certain operators, that residue material dropping into the hole as the casing is lifted is quite sufficient to seal the opening in the sand. Wells thus pulled and abandoned are a menace, not only to the coal industry, but also to the future production of oil and gas.

In the Ohio stripper fields various methods of sealing sands have been tried and results checked over a period of years. It has been found that a filler of residue, placed over a plug in a sand is more vital to a permanent seal than is the type of plug itself. This filler, whether applied by hand, or allowed to fall in as the casing is lifted, must be resilient enough to fill crevices and cavities in the walls, yet solid enough to pack into a continuous gas-proof mass. To get the twofold effect, operators are now using silt, or finely pulverized dry clay. The procedure is to raise the casing about 50 ft. off bottom. A plug is dropped into the opening in the sand and cemented. On top of the cement enough residue filler (dry) is poured to fill the hole 25 to 30 ft. above the cement. A drum of salt-water (100 gal.) is dumped in upon the filler, and casing pulling is resumed. By the time the final section of pipe is out, the wetted filler has settled enough so that the remainder of the hole can be filled to the top with whatever plugging material is available. An even more effective method is to mix the bottom silt or clay filler with coarse, common salt, in a ratio of 100 lb. of salt to 1000 lb. of silt. This mixture is dumped dry upon the cemented plug in the same quantities as when the silt is used alone. No water is applied. Action is due to the salt's affinity for water. Moisture is drawn in from the side-walls of the hole and the mass of filler is saturated more quickly and settles more thoroughly than when water is applied only on top. Where salt and salt-water are not easily obtained, operators use calcium chloride. The recipe is 6 lb. of calcium chloride in flake form to every 1000 lb. of pulverized silt or clay. Action and purpose is the same as when dry salt is used. Any one of these three methods creates a protective seal over the cemented plug, and eliminates almost every possibility of gas-leakage. In tests over a wide area of territory quantities of banana oil were placed in abandoned wells, on top of the cemented plug, but under the protective filler. In no case have operators detected fumes of the banana oil at the surface, nor have they penetrated any upper formations connected with the abandoned hole.

Salt, salt-water, or calcium chloride are available in practically all locations. Silt or clay are easily pulverized on the job. Five to ten dollars per well should cover all extra costs for an effective sand-sealing job, and when it is done the operator relieves himself of a possible risk to mining interests, and adds a protective measure to his own industry.

P 515.22

Extension Handwheel Aids Well Control

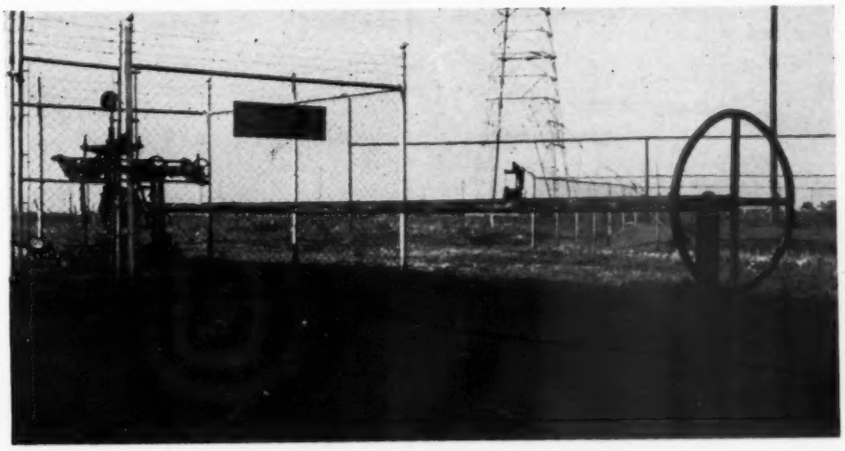
By
CHAS. C. LYNDE

ACCURATE and safe control of the master gate on a high-pressure well in the Texas Gulf Coast district is attained by attaching a blow-out preventer universal joint beyond the conventional handwheel of the gate, and pinning thereto a joint of heavy 2-in. pipe. On the other end of this pipe, and supported by a post at this point, is affixed a large handwheel, formed by welding a circle of 1-in. pipe to a cross of the same material. This handwheel is large enough to give ample leverage to control the valve, even when manipulated by only one man.

The pipe circle forming the rim of the extension wheel is bent to form by the wrinkle method, affording a corrugated inner edge and aiding in obtaining a sure grip.

Chain and padlock around one spoke of the handwheel and the supporting post provide insurance against meddling or unauthorized operation of the extension.

Installed in this manner, it is not necessary for the switcher to enter the fenced enclosure or work directly adjacent to the well when it is flowing. With the added leverage afforded by the big handwheel, it eliminates the need of resorting to pipe wrench or other "cheater" when wheeling the gate under high pressure and consequent high starting torque.



Extension and large handwheel facilitate the closing of a high-pressure well and make it unnecessary for the switcher to work close to the wellhead

Running Tour
WITH MEN IN THE INDUSTRY

F. C. JONES, formerly district engineer at Oklahoma City, Oklahoma, for Phillips Petroleum Company, has been appointed well-servicing superintendent of the district.

F. E. THOMPSON, gasoline plant superintendent at Fairbanks, Texas, for Warren Petroleum Corporation, has been transferred to Salem, Illinois.

H. H. SHARKEY, engineer for The Texas Company, is now making his headquarters at Mineola, Texas. He has been at Woodsfield, Ohio.

RAY DIMIT, production engineer for the Shell Oil Company, Inc., has been sent from Tulsa to Healdton, Oklahoma.

WILLIAM FARRAR, geologist, Skelly Oil Company, is now making his headquarters at Jackson, Mississippi. He formerly was at Evansville, Indiana.

O. D. ALLISON, of the Los Angeles, California, petroleum engineering office of The Texas Company, has been transferred to the Signal Hill office and will make his headquarters at Long Beach.

R. P. McLAUGHLIN, Los Angeles, California, has resigned as general manager of Dominguez Oil Field, Inc., to operate independently. **HARRIS HAMMOND,** president, has moved to Los Angeles from New York City and taken charge of the California office.

WALDON SMITH, vice-president of the Luling Oil and Gas Company, San Antonio, Texas, has been placed in charge of the Jackson, Mississippi, offices of the company, recently opened. Others transferred to Jackson are **GEORGE CANNON,** attorney, and **C. W. MAGALIS,** geologist.

GEORGE J. TURNER has been made general superintendent of the Philtex Division of the Phillips Petroleum Company, Bartlesville, Oklahoma. Recently he has been superintendent for the company at Seminole, Oklahoma. **H. F. ZION,** formerly well-servicing superintendent at Seminole, becomes superintendent in that district. **S. J. BETZER** has been named assistant superintendent of the Philtex Division at Bartlesville.

R. G. MOSS, geologist for Phillips Petroleum Company at Evansville, Indiana, has been transferred to company headquarters at Bartlesville, Oklahoma.

J. W. de GROOT, chief engineer of the Bayonne, New Jersey, refinery of the Standard Oil Company of New Jersey, has been transferred to the Tuscarora Oil Company at Harrisburg, Pennsylvania, as chief engineer and assistant to the president.

JOHN BELCHER, of the production department of the Carter Oil Company, has sailed for Maracaibo, Venezuela, to assume duties with the Standard Oil Company of Venezuela.

L. M. GOLDSMITH, chief engineer of the Atlantic Refining Company, Philadelphia, Pennsylvania, recently was appointed a member of the executive power division of the American Society of Mechanical Engineers, and a member of the convention committee of the American Institute of Electrical Engineers.

C. F. ELLZEY, field superintendent for Shell Oil Company, Inc., has been transferred from the Hackberry district to the New Iberia district, both in the Louisiana Gulf Coast area.

WILLARD GILL, geologist for Pure Oil Company, who has been stationed in Illinois, is now in the Cumberland district, southern Oklahoma.

F. J. WOLFE, managing director of the Anglo-American Oil Company, Ltd., London, England, recently retired from active service.

ROBERT RANKIN, mechanical engineer, has been transferred by the Shell Oil Company, Inc., from Tulsa, Oklahoma, to Lyons, Kansas.

W. W. HAY, manager of pipe lines and communications for the Union Oil Company of California, has completed 25 years' service with the company.

RUFUS CLARK, petroleum engineer in the Ventura, California, area for The Texas Company, has been transferred to Long Beach.

M. G. HOFFMAN, chief geologist for Midco Oil Corporation, Tulsa, Oklahoma, has become service engineer and sales geologist for the Geochemical Service Corporation, Tulsa.

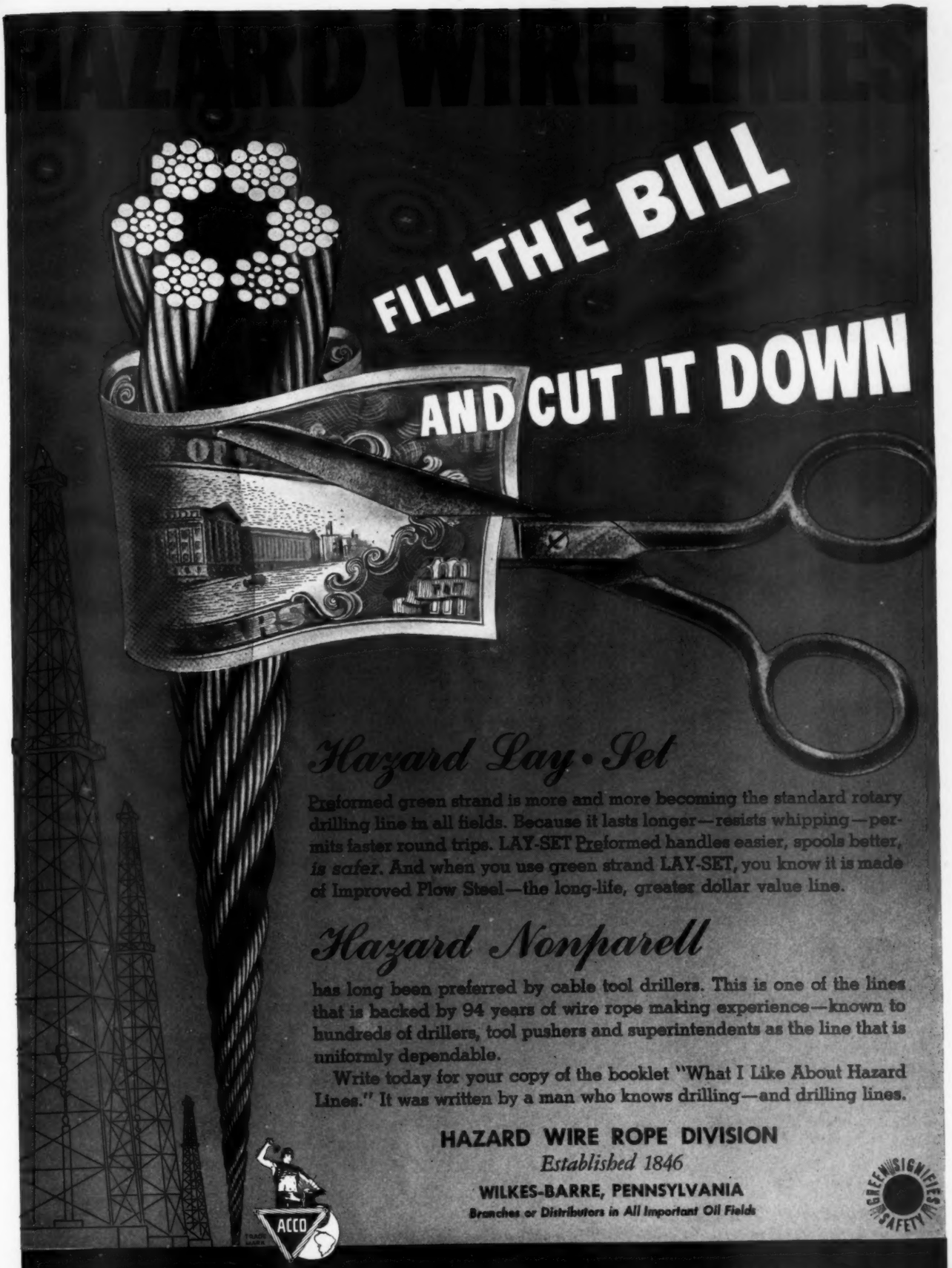
C. V. CONNER has been made superintendent of the Mountain States Gas Company, subsidiary of Pure Oil Company, to succeed **O. M. LOVELL,** who is retiring. His headquarters are at Dawes, West Virginia.

H. A. SPROWLS of Vincennes, Indiana, has resigned as vice-president of the Kentucky Natural Gas Corporation and will engage in producing activities in Illinois.

D. E. MORGENSTERN, of Poland, who came to this country two years ago, has accepted a position with the General Geophysical Company at Houston, Texas. Morgenstern studied mining engineering in Poland and at L'Université De Liége, Belgium, then

D. E. MORGENSTERN

came to this country to specialize in petroleum engineering. He graduated from M.I.T. in 1939 and then studied geology and engineering in the graduate school at Columbia University. At present Morgenstern is working on a seismograph crew in Ohio.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AND CUT IT DOWN
Hazard Lay • Set
Preformed green strand is more and more becoming the standard rotary drilling line in all fields. Because it lasts longer—resists whipping—permits faster round trips. LAY-SET Preformed handles easier, spools better, is safer. And when you use green strand LAY-SET, you know it is made of Improved Plow Steel—the long-life, greater dollar value line.
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HOWARD R. SALISBURY has been appointed manager of the Air Reduction Sales Company at Philadelphia, Pennsylvania. Sailsbury has been connected with Airco for 15 years. He was manager at Bettendorf, Iowa, for 2 years and assistant manager at Philadelphia for the last 6 years. He is also a past chairman of the Philadelphia Section of the American Welding Society. Salisbury succeeds **WILLIAM W. BARNES,** retired. **H. B. SEYDEL,** formerly assistant sales manager of the New York District, has been appointed assistant manager at Philadelphia.

D. K. HUTCHCRAFT, Mid-Continent sales manager of Clark Brothers Company, Inc., has returned to his Tulsa, Oklahoma, office after being absent for most of the month of July. A business trip to Colorado Springs and vicinity occupied the earlier part of the month, and was followed by a ten-day visit in Miami Beach, Florida.

O. H. REAUGH, Gulf Oil Corporation district engineer at Seminole, Oklahoma, is now making his headquarters at Centralia, Illinois, being engaged in the same kind of work in that area. **E. J. GALLAGHER,** who has been in charge of well-conditioning work, has been promoted to district engineer at Seminole.

C. R. NICHOLS has resigned as district geologist for Sun Oil Company at McAllen, Texas, to engage in consulting work. He will make his headquarters at McAllen. Succeeding him with Sun is **L. C. SMITH,** formerly of the Dallas, Texas, office of the company.

R. E. ADAMS has returned to the Cities Service Oil Company's oil production division general offices at Bartlesville, Oklahoma. For the last three years he has been on special assignments in Kansas, supervising proration in that area.

B. H. SPENCE has been promoted to superintendent of the Oil City, Pennsylvania, district by the South Penn Oil Company. He succeeds **CLARENCE GRAHAM** who has been named superintendent of the Bradford district.

J. F. BARTHWICH, JR., has been appointed field engineer by the Mississippi State Oil and Gas Board, and will be placed in charge of operations in the Tinsley and Pickens fields.

R. E. McPHAIL, geologist for the Phillips Petroleum Company, has been transferred to Corpus Christi, Texas, from Wichita Falls.

FRED VAN BILDERBEEK, formerly at The Hague, Holland, with Royal Dutch Shell, has been studying operating methods in the United States and will leave soon for the Dutch East Indies.

F. R. CORBELL, superintendent of the Lea County, New Mexico, district for the Magnolia Petroleum Company, has been transferred to Alice, Texas, where he will occupy a similar post. **O. A. STOUT,** production superintendent at Wewoka, Oklahoma, moves to Lovington, New Mexico, to replace him.

J. M. LILLIGREN, superintendent for the Sinclair Prairie Oil Company, has been transferred from Covington, Oklahoma, to Parkersburg, West Virginia.

W. F. DALTON, petroleum engineer for Hunt Oil Company, has been transferred from Dallas, Texas. to Shreveport, Louisiana. His company recently opened an office in the latter city, of which Dalton is in charge.

K. C. SPOONER, formerly division geologist for the Atlantic Refining Company at Houston, Texas, now has his headquarters in Jackson, Mississippi, where he is division geologist. **H. H. TREAGER** has been transferred from Shreveport, Louisiana, to Houston to take over the work there.

RAY A. GREGORY, Petrolia, Ontario, Canada, has been placed under contract to drill by Trinidad Leaseholds and will leave soon for Trinidad, British West Indies.

S. K. LOY, chief chemist at Casper, Wyoming, for the Standard Oil Company of Indiana, has resigned to devote his full time to private business. He is president of the Riverton Petroleum Company.

FRANK WILLIAMS, who has been manager of the district office at Corsicana, Texas, for the Lone Star Gas Company, has been promoted to division superintendent. He succeeds **LEON M. SCHOLL,** who has been transferred to the Denison-Sherman division with headquarters at Denison, Texas.

C. D. GARD recently was made superintendent of natural gasoline operations by the Union Oil Company of California.

J. R. PEMBERTON has opened an office in Los Angeles, California, to practice as a consulting petroleum engineer. He recently was retired as California oil umpire.

CHESTER BAIRD, chief geologist for the Mene Grande Oil Company, recently returned to Maracaibo, Venezuela, after spending some time in the United States.

R. A. MILLER, superintendent of production in the Union-Lisbon district, Arkansas, for Magnolia Petroleum Company, has been transferred to the Talco field, Texas.

J. I. TUTTLE, district superintendent for the Humble Oil and Refining Company, has been moved from the Government Wells area of Texas to Colorado, Texas, where he will be in charge of all operations. **H. P. KEMP,** who has been in charge of the Greta district, takes over at Government Wells, and **FRANK BASS** replaces Kemp.

F. G. PHILLIPS, engineer for Shell Oil Company, Inc., has been transferred from Iowa, Louisiana, to Kilgore, Texas.

JOHN SURBER, who has been warehouse foreman at Seminole, Oklahoma, for Sinclair Prairie Oil Company, has been made assistant construction superintendent.

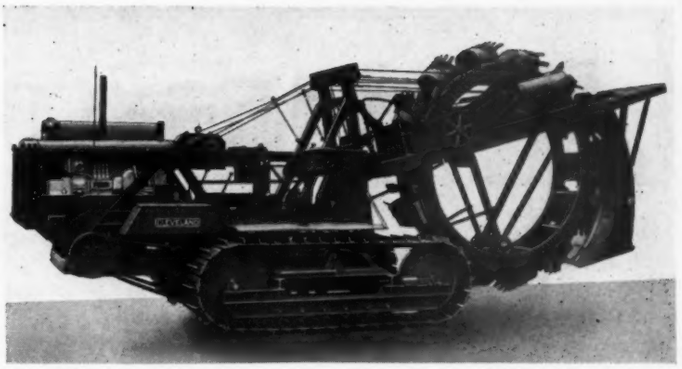
SAMUEL VAUCLAIN, III, geologist, Sun Oil Company, is now stationed at Hattiesburg, Mississippi, having been transferred from Jackson.

R. R. RICE, petroleum engineer for The Texas Company, has been moved from Tulsa to Seminole, Oklahoma.

MORRIS R. PITTMAN, drilling engineer, Standard Oil Company of Venezuela, Caripito, Venezuela, has been in the United States on business for his company.

ON YOUR NEXT JOB . . .

GET BOTH { FOOTAGE and ECONOMY } with CLEVELANDS



When you buy "Clevelands" you get the most for your money, because they give you BOTH Performance AND Economy.

PERFORMANCE—because they have the power to conquer tough digging conditions with the speed to maintain high daily footage. ECONOMY—Because the strength and the supreme excellence of their construction means long life and low operating costs.

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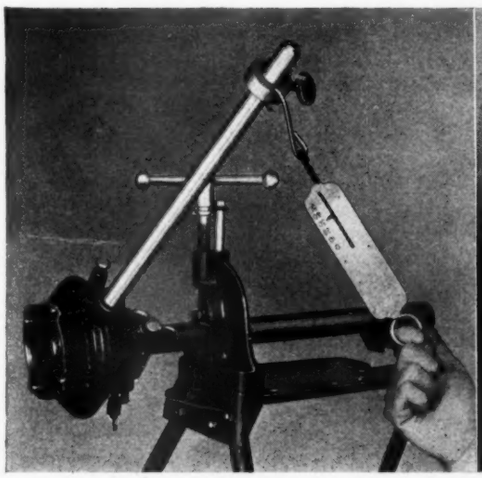


DON'T FAIL TO SEE THE NEW "TOLEDO" SIMPACT–

—1" to 2" self-contained ratchet threader on display at your dealer's salesroom.

Examine it closely, note the simple, easy, positive size change. Sizes are changed in a fraction of the time ordinarily required. See the oil pockets which are filled with oil at start of thread and the oil continues to drip on the dies and pipe as tool is revolved. Note the accurate, sturdy centering device. Three broad-faced chuck jaws grip the pipe and center the tool accurately. You will be amazed at its easy operation. It is truly the finest 1" to 2" self-controlled tool. Buy from your local dealer—you will like this new "TOLEDO."

"TOLEDO" THE TOLEDO PIPE THREADING MACHINE CO. "TOLEDO"
TOLEDO, OHIO NEW YORK OFFICE, 72 LAFAYETTE STREET

LAUGH WITH BARNEY

"Who you shovin'?"
"Dunno, what's your name?"

* * *

Sweet Young Thing: I love you more than Life itself, or any other ten-cent magazine.

* * *

"Waitress, what's wrong with these eggs?"
"I don't know. I just laid the table."

* * *

"Oh, dear, I've missed you much!" —and she raised her revolver and tried again.

* * *

"I like psychology when it isn't over my head."
"That's the way I feel about pigeons."

* * *

Then there's the chap who went spooning the other night with his sugar, and found there was nothing stirring.

* * *

He: But, dearest, if we buy this car, how're we going to pay for it?
She: Let's not confuse the issue by considering two problems at once.

* * *

He: Here's how . . .
She: Say when . . . I know how.

* * *

This month's absent-minded contest was won by the druggist who was asked if he had a wife and replied no, but he had something just as good.

* * *

Prof: Will you please explain the difference to me between shillings and pence?
Frosh: You can walk down the street without shillings.

* * *

The Lord seems to compensate those who aren't important by making them feel important.

* * *

He: Can I take you home?
She: Sure, where do you live?

* * *

Alien Lexicon

We're told the story is true.

Three refugees, recently arrived in this country, were attending school to learn the English language.

One night after classes, they were discussing conditions at home. As the subject grew more advanced, one of them said:

"My wife is unbearable."

"Tsk, tsk," corrected the second refugee, "That iss the wrong word—you mean 'inconceivable.' "

"You are both wrong," interrupted the third. "You should go to school longer and learn the right word iss 'impregnable.' "

* * *

Hotel Clerk: Why don't you scrape that mud off your shoes before you come in here?
Backwoodsman: What shoes?

* * *

Said an excited citizen to a candidate: "I wouldn't vote for you if you were the Angel Gabriel."

To which the politician replied: "If I were the Angel Gabriel, you wouldn't even be in my precinct."

* * *

Mother: Jimmy, I wish you'd learn better table manners. You're a regular little pig at the table.

After a deep silence on Jimmy's part, his father, wishing to further impress him, said: "Do you know what a pig is, Jimmy?"

"Yes, sir," Jimmy replied, "it's a hog's little boy."

* * *

"It's wonderful what some insects can do. A grasshopper can jump 200 times its own length."

"That's nothing. I once saw a wasp raise a 200-pound man three feet off the ground.

* * *

Joe: I was held up by two men last night.
Bill: Where?
Joe: All the way home.

* * *

Officer: Now tell me what is your idea of strategy?
Private: It is when you don't let the enemy know that you're out of ammunition, but keep right on firing.

* * *

Mrs. Jones: There! Broke my looking glass! Now I suppose I shall have seven years' bad luck.
Mrs. Brown: Don't you believe it, Mrs. Jones. A friend of mine broke hers and she didn't have seven years' bad luck. She was killed in an explosion the next day.

Fanny: Last night my boy friend wanted to sit in his car and neck, and I wanted to sit on our front porch and hold hands.
Tiny: Well, what did you do?
Fanny: We finally compromised on the living-room divan.

* * *

Barrister (for motor accident victim): Gentlemen of the jury, the driver of the car stated he was going only four miles an hour. Think of it! The long agony of my poor, unfortunate client, the victim, as the car drove slowly over his body.

* * *

On the "Laugh With Barney" page in the May issue of *The Petroleum Engineer* there appeared two contributions by F. Harold Gray, London, England, representative of the Reed Roller Bit Company. Concerning the aftermath of these stories Mr. Gray writes:

"According to Will Shakespeare—'Some are born great, some achieve greatness, and some have greatness thrust upon them'. I have apparently had greatness thrust upon me in that my name has been blazoned around the world as a contributor to *The Petroleum Engineer.* From all quarters of the globe and from all offices in London and the Provinces I have had letters and messages calling attention to the prominence given to my name in connection with two of Barney's stories."

Here is Mr. Gray's latest contribution:

"He was a tough stoker from the British navy, operating in Norwegian waters, somewhere around Narvik. He had been three months at sea, without a spot of 'shore leaf', and he longed for the time when they would make a port so that he could get a run ashore.

"The great day came at last and he found himself ashore. He got a much-needed hair cut, sprinkled himself lavishly with cheap perfume, and fortified himself in a nearby bar with several drinks of aquavit (which appears to be Scandahoovian for corn likker). Then he sallied forth, went up to a passing pedestrian and said, 'Say, Mister, can you tell me where I can find this iron ore I've been hearing so much about?' "

AN OPEN LETTER TO:

BAKER OIL TOOLS, INC.

BAKER OIL TOOLS, INC. SERVING THE WORLD

MAIL ADDRESS: POST OFFICE BOX 127 VERNON STATION

CABLE ADDRESS "BACASO"
MAIN OFFICE AND FACTORY
6000 SO. BOYLE AVENUE

LOS ANGELES, CALIF.

OPERATORS INTERESTED IN CEMENTING

It is generally agreed that the proper landing and cementing of casing is one of the most important steps in drilling a modern oil well.

But exactly what does the term "cementing" mean? It used to be that to many operators "cementing" meant merely pumping the desired amount of slurry down the casing and discharging it through practically any type of Shoe on the end of the string . . . hoping enough cement would be placed around the Shoe and behind the pipe to get a shut-off and reenforce the casing. Later, when the Shoe was drilled out and the job tested, if it was found dry, the cementing operation was considered a complete success.

But times have changed, and so has the modern operator's conception of what a "good" cement job not only "is" but "must be." Today a cement job must stand TWO tests . . . one the water Shut-off Test . . . and the other the test of time, for with proration and other factors restricting and regulating oil production, it is becoming increasingly important that the cement job must stand for only be maintained but actually prolonged if the initial investment, to say nothing of anticipated profits, are to be recovered.

This long range, profit-return program calls for a consideration of all factors which influence the life expectancy of an oil well . . . which goes right back to "cementing," for the effectiveness of the cement job performed determines to a considerable extent the length of time that an oil well will be a profitable producer.

Baker Oil Tools, too, has recognized this fact and has accordingly made available to the oil industry a type of Shoe that field records have proven to be the most efficient unit for Guiding, Floating and Cementing casing that has yet been devised. It is called the Baker Cement Wash-Down Whirler Float Shoe (see illustration). This type of Shoe is designed to afford results that not only insure the safe landing of casing strings but also the best possible chance for a successful cement job under all conditions . . . the type of job that has the best chance to stand up for the normal life of an oil well.

If you have not investigated Baker Cement Wash-Down Whirler Float Shoes it will pay you to do so.

Yours very truly,

J. Sutter

BAKER OIL TOOLS, INC.
General Manager

Baker Cement
Wash-Down Whirler
Float Shoe

FOR COMPLETE DETAILS SEE PAGES 223-225 OF THE BAKER SECTION OF THE 1940 COMPOSITE CATALOG

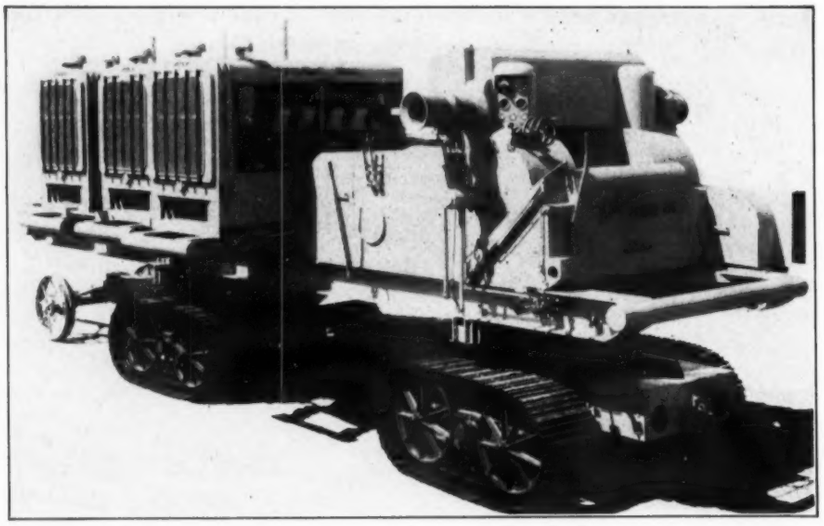
BAKER OIL TOOLS, INC.

MAIN OFFICE AND FACTORY
6000 So. Boyle Ave., P. O. Box 127, Vernon Station
Los Angeles, California
CENTRAL DIVISION OFFICE AND FACTORY
6023 Navigation Blvd., P. O. Box 3048, Houston, Texas
EXPORT SALES OFFICE: 19 Rector St., New York, N. Y.

MACHINERY and EQUIPMENT

Wilson Rig With Special Features to South America

JOHN H. WILSON, president, Wilson Manufacturing Company, Inc., Wichita Falls, Texas, announces the shipment of a Wilson Giant Model Streamlined Rig, having many special features, to South America.



The Giant Rig will drill wells to 6000 ft. with 4½-in. drill pipe and to 8000 ft. with 3½-in. drill pipe.

It is equipped with:

Friction clutches on both drum clutches, on rotary drive, and on pump drive through a two-pump jackshaft.

Air controls on both drum and chain transmission clutches.

Centrifugal pump driven from the drawworks engine output shaft that will supply water for the cooling system for both drum clutches and brake rings. A single-stage air compressor also driven from the drawworks engine output shaft supplies air under pressure for operation of drum and transmission clutches.

Brake rings are specially flame-hardened and ground.

The rig is powered by three Caterpillar D-17000 full-Diesel engines, equipped with a two-pump jackshaft from the rear or pump engine. Oil-bath chain compound drives are so arranged that the power from the three engines may be combined either to the drawworks or the pump drive, so that two engines can be used on the drawworks and one on the pump or two on the pump and one on the drawworks.

The entire unit is mounted complete on a Model ET 1025 Athey truss wagon having 24-in. heat-treated tracks. This arrangement means that no dismantling of the unit is necessary when moving from one location to another. The unit will remain mounted on the truss wagon.

The only disconnection necessary will be breaking the chain to the rotary table and taking the V-belts off the pump pulley or pulleys.

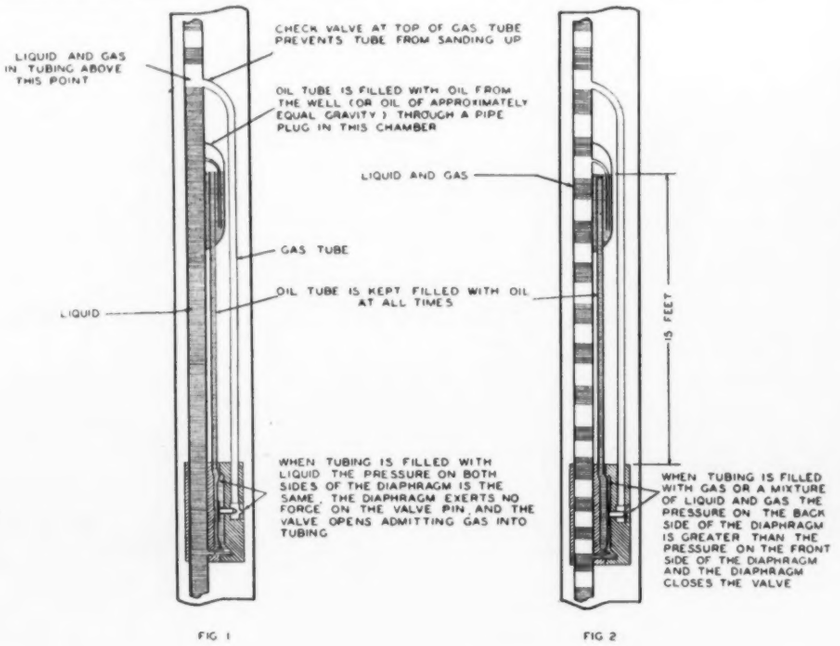
McEvoy Fluid Weight Flow Valve

FOLLOWING intensive research work and field testing during the last two years, a new flow valve is now being offered to gas-lift operators by McEvoy Company, Texas at Bilby Street, Houston, Texas, that operates on an entirely different principle from any other gas-lift device now available, it is stated.

The new McEvoy fluid weight flow valve is constructed without the use of springs and its operation is based on the differential pressure between a hydrostatic head of plain well fluid and the hydrostatic pressure of an equal head of a mixture of gas and well fluid. These heads are exerted, one inside the tubing, the other in a small tube welded to the outside of the tubing, as shown in Fig. 1. Each of these columns is connected to opposite sides of the diaphragm controlling movement of the valve.

When the hydrostatic pressures of these two heads of fluid are equal, the

(*Continued on Page 116*)


LIQUID AND GAS IN TUBING ABOVE THIS POINT
CHECK VALVE AT TOP OF GAS TUBE PREVENTS TUBE FROM SANDING UP
OIL TUBE IS FILLED WITH OIL FROM THE WELL (OR OIL OF APPROXIMATELY EQUAL GRAVITY) THROUGH A PIPE PLUG IN THIS CHAMBER
LIQUID AND GAS
GAS TUBE
OIL TUBE IS KEPT FILLED WITH OIL AT ALL TIMES
LIQUID
15 FEET
WHEN TUBING IS FILLED WITH LIQUID THE PRESSURE ON BOTH SIDES OF THE DIAPHRAGM IS THE SAME, THE DIAPHRAGM EXERTS NO FORCE ON THE VALVE PIN, AND THE VALVE OPENS ADMITTING GAS INTO TUBING
WHEN TUBING IS FILLED WITH GAS OR A MIXTURE OF LIQUID AND GAS THE PRESSURE ON THE BACK SIDE OF THE DIAPHRAGM IS GREATER THAN THE PRESSURE ON THE FRONT SIDE OF THE DIAPHRAGM AND THE DIAPHRAGM CLOSES THE VALVE
FIG 1
FIG 2

62 B.C.—The Pons Fabricus at Rome built in 62 B.C. First bridge whose arches do not appear as semi-circular.

1933 A.D.—One of the greatest suspension bridges in the world is the Golden Gate Bridge which spans San Francisco Bay. Its overall length, including approaches, is 9,217 feet. Feature is the graceful central span of 4,200 feet supported by two massive towers each 746 feet high.

Continuous Improvement

IS OUR WATCHWORD, TOO

Gray's Systems of Well Control were pioneered and developed to provide complete control during the entire sequence of operations from drilling, through production inclusive. Gray's policy of continuous improvement has meant continuously better, more flexible, systems of well control. But this policy does **not** result in obsolescence of previously manufactured assemblies. Rather, refinements can be added at small cost to any Gray assembly thus making for long-range economy.

From the beginning Gray products have been made from the finest materials procurable and engineered according to the most advanced principles of construction. Not only are they designed to serve adequately the needs of today, but also they have built in them the unseen ability properly to service the needs of tomorrow.

"Continuous Improvement" sums up the story of Gray progress.

GRAY
TOOL COMPANY

H O U S T O N

***West Coast Distributors:* WAGNER-MOREHOUSE, INC., Los Angeles**

valve opens and permits a charge of gas to enter the tubing from the casing. The energy of the admitted gas begins the work of lifting the fluid to the surface. As flowing proceeds, the gas pressure lowers the fluid level in the casing past the next lower valve. This depression of the fluid level establishes a condition of equilibrium across this valve, thus actuating the valve and permitting gas to enter the tubing at this level.

When this aerated column passes the upper valve it immediately causes a differential in pressure between the tubing fluid and the plain well fluid in the tube. This differential in pressure across the diaphragm, created by the fluid in the tube having a greater density than that of the oil-gas mixture within the tubing, causes the upper valve to close, as shown in Fig. 2.

Thus, until the lower valve is reached and has been opened, the upper valve remains open, permitting gas to continue entering the tubing. This is considered an important point by the manufacturer inasmuch as it definitely eliminates the possibility of being unable to unload from one valve to another with the maximum input pressure available.

The successive opening and closing of valves continues automatically until the working fluid level of the well is reached.

It is believed by the manufacturer that this entirely new principle will allow considerably wider spacing of the valves than has been possible in the past. The pressure in the casing has nothing to do with operation of the valve whatsoever, except in determining the valve spacing.

The valve has purposely been kept simple in construction and operation and devoid of complicated mechanism. All elements of the valve are mounted on the outside of the tubing—leaving an unrestricted passage through the tubing to permit running a bottom-hole pressure bomb or other instruments in the well. All parts have been designed to provide trouble-free operation over a reasonable period of time. For example, the diaphragms of these valves have been flexed on a test rack more than 20 million times without failure. The reason this test was stopped was due to the testing machine wearing out.

The McEvoy Company, in offering this valve, places emphasis upon the fact that it is not intended as a "cure-all" for all types of gas-lift problems. As developed at present, the valve is particularly adapted to wells in which a high working fluid level may be maintained, it is stated.

The valve is available in both 2-in. and 2½-in. sizes. Both sizes may be installed on tubing within 7-in. O. D. casing but only the 2-in size may be run in 5½-in. O. D. casing. In a well equipped with 5½-in. O. D. casing and 2½-in. tubing, the 2-in. valves may be installed readily by swaging at the valves.

Experience with the valves thus far has indicated that little difference in operation can be observed whether a standing valve is used or not.

PATTERSON-BALLAGH PIPE WIPER

SAVES
mud weight material

PREVENTS
loss of mud on floor

CLEANS
pipe and tools

REDUCES
use of water

One Louisiana operator reports saving of 2 to 4 sacks of mud weight per trip by use of this Pipe Wiper. Still another operator near Bay City reports a saving of 18 to 20 sacks per trip. "We figure our Pipe Wiper paid for itself the first trip; however, it has made 50 to 75 trips and is still in good condition," he declares.

It's Economy to Use

PATTERSON-BALLAGH PROTECTORS, STABILIZERS, PIPE WIPERS, WIRE LINE GUIDES and SUCKER ROD WIPERS

Each is a proven success!

PATTERSON-BALLAGH CORPORATION... *Los Angeles, Houston, New York City*

Beaver No. 71 Kit Box

THE new Beaver No. 71 Kit Box holds a plain or ratchet threader and ten sets of dies, for threading pipe

and bolts. The dies can be changed in 20 seconds and are adjustable for making standard threads or variations. The

dies adjust as a single unit, assuring uniform cutting, the manufacturer states. A smooth-working universal chuck eliminates loose bushings, it is stated.

The equipment threads pipe of ⅛ in. to ¾ in. diameter, and bolts of ¼ in. to 1 in. diameter (by $\frac{1}{16}$ths).

For further information write Beaver Pipe Tools, Inc., Warren, Ohio.

Axelson On-Or-Off Attachment

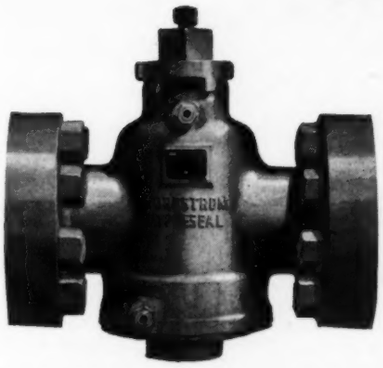
THE Axelson On-Or-Off Attachment for connecting or disconnecting the sucker rods at the pump

provides insurance against stripping jobs in any installation, the manufacturer asserts. To make the connection the bowl and socket are lowered on the end of the rod string until it telescopes over the gunbreech threaded mandrel that is attached to the lower section of the rods at a point far enough above the pump to prevent sanding-up. The cam unit will turn the socket into proper contact with the mandrel when the rods are rotated to the left from one to two turns per 1000 ft. of depth, it is stated. This rotation is only to allow engagement and is not great enough to cause joints to become unscrewed. When engaged, the unit is as solid as a one-piece coupling, and is sealed so that no foreign matter can enter, the makers state. Disengagement is effected by setting the rods down and rotating to the right a sufficient number of turns to overcome the natural spring of the rods and cause rotation of the bowl and socket. Coupling and uncoupling may be performed as often as desired without withdrawing the pump or plunger assembly from the well.

The equipment is manufactured by the Axelson Manufacturing Company, Los Angeles, California.

Lubricated Plug Valve Tested to 15,000 Lb.

DEVELOPMENT of a lubricated plug valve capable of handling a working pressure of 7,500 lb. and tested to 15,000 lb. is announced by Merco Nordstrom Valve Company. It is made of special alloy steel with both plug and interior contact surfaces



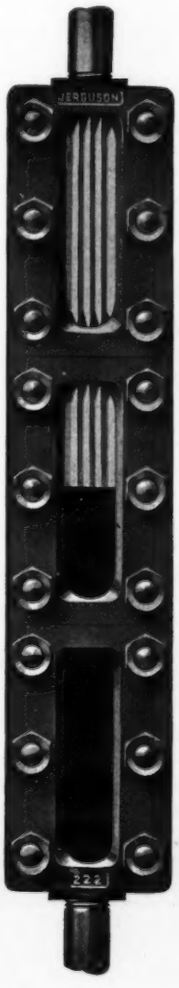
faced with Merchrome, a recent development in hard-facing.

This heavy-duty plug valve is the result of several years of development work in the research laboratories of the manufacturer. It was principally developed for recycling services in gas and oil fields, but has other applications in refineries and in processes where tremendous pressures are carried. Extremely heavy flanges and sidewalls are incorporated to prevent body distortion.

Further details may be obtained from Merco Nordstrom Valve Company, 400 Lexington Avenue, Pittsburgh, Pennsylvania.

JERGUSON

BE SURE
that the name
JERGUSON
is on your Gages



Jerguson Reflex and Transparent (through vision) Gages have been noted for over 30 years for accuracy and dependability.

Reflex Gages indicate the liquid level, no matter what the color of the liquid. Ideal for tanks, towers, still, etc., because the . . .

EMPTY SPACE SHOWS
WHITE

LIQUID LEVEL APPEARS
BLACK

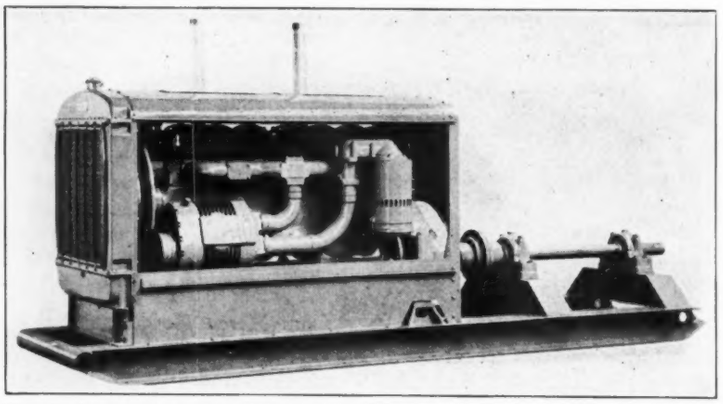
Jerguson Transparent (through vision) Gages for showing color and density of liquids, are also noted for their accuracy and dependence.

Jerguson Gages Are Best
By Every Real Test

CATALOG ON REQUEST

JERGUSON GAGE & VALVE CO.
81 FELLSWAY
SOMERVILLE, MASSACHUSETTS

Murphy Diesel Oilfield Type Power Unit



THE Murphy Diesel Model ME-650, 200-hp. oilfield type power unit has recently been introduced by the Murphy Diesel Company, 5317 West Burnham Street, Milwaukee, Wisconsin.

The engine is a supercharged 6-cylinder unit, 5¾ by 6½, 1200 r.p.m., 200 hp. intermittent rating, 160 hp. continuous rating, with unit fuel injectors, one for each cylinder, 3½ percent regulation hydraulic, servo-type governor embodying safety protection against failure of lubricating oil pressure, high velocity and high volume water circulating system, oil-bath type air cleaner, and complete filtering system for the fuel and lubricating oils. All crankshaft and camshaft bearings are of the precision, copper-lead alloy, steel-backed type. The pistons are oil cooled. Two inlet and two exhaust valves are provided for each cylinder.

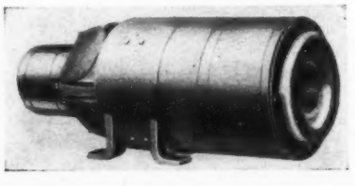
The clutch is of the enclosed twin-disk type, and, as shown, the power unit provides an extension shaft of ample length for oil-field uses, running in two pillow block bearings and coupled to the engine through a flexible coupling. The overall length of the unit as shown is 170 in. and the overall width 40 in. The shipping weight is 8500 lb., making a compact and portable enough unit for the demands of a heavy-duty power unit in oil-field service, the manufacturer points out.

The engine enclosure includes side doors not shown in the accompanying illustration.

Similar power units, rated at 105 hp. for intermittent service and 85 hp. for continuous service with the 4-cylinder Model ME-4 engine, and 160 hp. intermittent and 128 hp. continuous with the 6-cylinder Model ME-6 engine are also available.

GE Speed-Variator Equipment

THE General Electric Company, Schenectady, New York, has announced as a standard "unit" a complete speed-variator equipment oper-

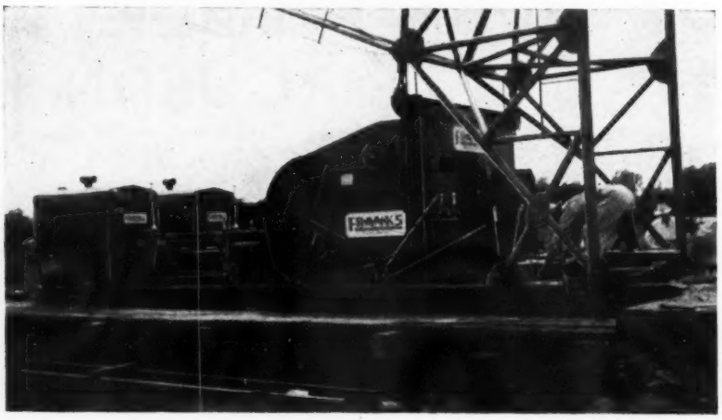


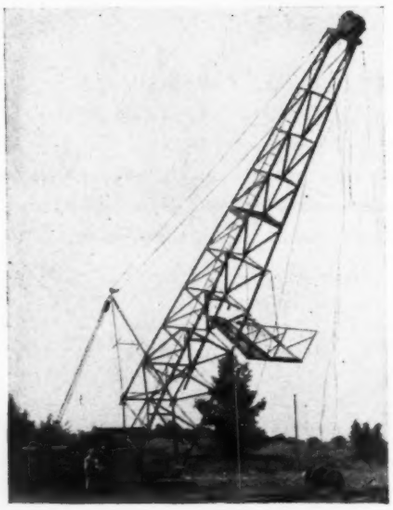
ating from an a-c. source of supply to provide wide ranges of adjustable speed by means of the well-known generator-voltage-control scheme. Each equipment consists of an adjustable-speed, d-c. motor, an adjustable volt-

PERFECT for ILLINOIS

FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS

SKID TYPE PORTABLE ROTARY DRILLING RIG





ABOVE—On location in Illinois.
BELOW—Showing unit as derrick is being raised.

ECONOMICAL
for either

- "SLIM-HOLE" DRILLING
- MEDIUM DEPTH STANDARD DRILLING

Power plants, rotary table, draw-works and derrick all unitized on single skid, frame of which may be moved in one or two sections. Operates with 3-man crew. Least disassembling for moving. See Franks section in Composite Catalog or write Franks Manufacturing Corporation, Tulsa.

FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS
TULSA, OKLAHOMA
Drawer 137, Whittier Sta., Tulsa, Okla.
Cable Address: FRANSI
Export Office:
149 Broadway, New York, N. Y.

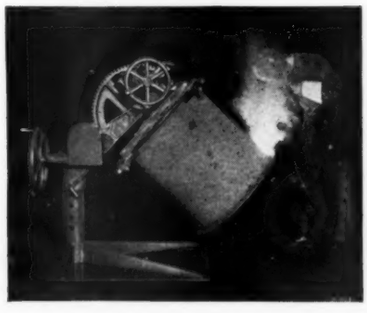
age motor-generator set with control, and a separately mounted generator-field rheostat. Standard speed ranges are available to 16:1 ratio.

The adjustable-speed, d-c. motor can be mounted directly on the driven machine, with speed-changing control mounted nearby. The units are designed to operate from 3-phase, 60-cycle, 220-, 440-, and 550-volt a-c. power. The potentiometer-type generator-field rheostat provides speed changes in small increments over wide ranges.

The speed variator is suitable for many applications where adjustable speed has a direct bearing on control of quality and efficient output of the driven machine, the manufacturer asserts. This flexible power medium is applicable to material handling operations throughout the entire industrial field. Heavy-starting duty and slow-threading speed, quick stopping and fast acceleration, coupled with flexible control, are some of the major features of this equipment.

C-F Model 12 Positioner

RECENTLY added to the C-F line of welding stands is the new size, Model 12 Positioner, capacity 1200 lb. Like other positioners of this line, the new Model 12 can be tilted a total of 135° from horizontal and table can be revolved through a full circle (360°) regardless of angle of tilt. The table is removable for attachment of special jigs or fixtures and is adjustable in height. By mounting the positioner-operating mechanism on a special base, extremely large and bulky work can be fully rotated when tilted either vertical or a total of 135° without any interference from floor or pedestal mounting, the manufacturer states.



This new unit can be supplied fully powered with independent motor and controls for table tilt and table rotation. Power for table rotation can be supplied with either constant- or variable-speed drive. The Model 12 can also be supplied for manual operation with independent handwheel for table tilt and table rotation, or a combination of manual and power operation.

It is asserted that the universal adjustment of table of this positioner reduces the number of passes required, reduces rod consumption, and assures a better weld by permitting all work to be done in a horizontal trough. Much welding, hoist and crane time are saved by positioning assemblies, and, with variable-speed power operated table rotation, rod may be held in one position while work is rotated at proper welding speed.

C-F Positioners are manufactured by the Cullen-Friestedt Company, Chicago, Illinois.

Water Encroachment!

Water problems need never be unexpected or unnecessarily expensive, if wells are checked periodically with Humble Type SUBSURFACE RECORDING INSTRUMENTS.

The information secured by the use of these instruments will enable operators to:

Prevent premature and uneven water encroachment. Locate water coming through casing or from the formation. Determine presence of water in the producing formation. Detect water flow and water movement behind casing. Detect presence of water in bottom of the hole, etc.

The Humble Type—1¼" O.D. SUBSURFACE PRESSURE GAUGES, HIGH PRESSURE SUBSURFACE SAMPLER, and the SUBSURFACE RECORDING THERMOMETER are manufactured, exclusively, in the specialized plant of E.L.I. The instruments are guaranteed for perfection of workmanship, materials, and performance in the work for which they are designed. Service and replacement parts are quickly available.

Write for descriptive bulletins.

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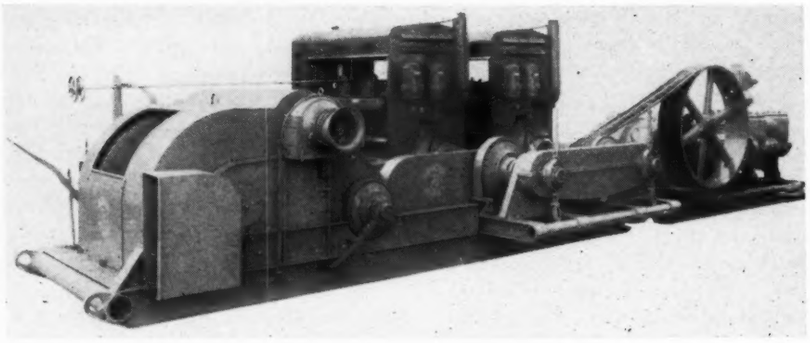
CONSULTING ENGINEERS AND MANUFACTURERS

TULSA, OKLAHOMA, U. S. A.

Brewster Model VO-170 Portable Drilling Rig



THE new Model VO-170 portable drilling rig, manufactured by The Brewster Company, Shreveport, Louisiana, is powered by two 180-hp. motors suitable for drilling to 5000 ft. A new type of compounding drive makes the power unit sturdier and more compact, the manufacturer states. The entire operation of the rig is made extremely flexible by the use of three friction clutches on the rotary drive, transmission drive, and pump drive. Each motor is also controlled by a friction clutch. The oilbath transmission employed on this rig is of exclusive Brewster design and has 4-speeds forward and 1-reverse. The brakes are 9 in. by 48 in. and the drumshaft is 7 in. and made of SAE 4140 steel. Roller bearings are used throughout the rig.

The outside appearance of the rig is exceptionally streamlined with all moving parts protected by guards and covers and the entire rig unit is made so compact that the overall length is only 19 ft. 6 in. The pump shown with this rig is 6 in. by 16 in. and is operated by V-belt drive.

The other Brewster rigs in the "VO-Series" include sizes recommended for drilling from 3,000 to 10,000 ft.

You *save* in *two ways* when you use 3-way or 4-way Homestead Plug Valves as flow changers, switching valves, or to operate single or double-acting pistons not requiring a mid-position shut-off.

1. **You save in first cost, maintenance and operating time by requiring fewer valves and fittings.**
2. **You save by getting Homestead's typical long, trouble-free operation, and extremely low cost-per-year valve service.**

These valves are available in "Lever-Seald" and "Cam-Seald" types, sizes from ½-inch to 12-inch, cast in bronze, acid-metal, semi-steel, steel, stainless steel, Monel, Ni-Resist, or special alloys for specific jobs; for temperatures to 1000° F. and corresponding pressures. Get this double economy; specify and order Homestead 3-way and 4-way Plug Valves.

Send for Valve Reference Book No. 38; and for special quantity prices on your valve requirements.

HOMESTEAD VALVE MFG. COMPANY
P. O. BOX 14 CORAOPOLIS, PA.

HOMESTEAD VALVES
QUARTER TURN VALVES: STRAIGHT WAY, THREE WAY, FOUR WAY, LUBRICATED TYPE, LEVER TYPE PLUG
PROTECTED SEAT VALVES: HYDRAULIC & G. O. PAT. OPERATING, REMOTE CONTROL, HYDRAULIC BEVELING, ROSS AIR SHUT-OFF VALVES, ADAMCO BLOW-OFF VALVES

Line-Roller No. 7 Roller Rod Line Carrier

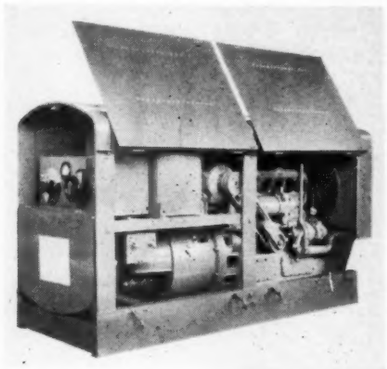
LINE-ROLLER No. 7 is an improved roller rod line carrier of streamline design. The sheave wheel has an extra deep groove accommodating to 1-in. pull rods. The "railroad track" groove design carries any size pull rod on two sides in a true rolling movement. The hub is filled with special bearing lubricant that does not require replenishing due to the permanent type grease seals used. To prevent any possibility of binding from either radial or thrust loads, the sheave wheel is carried on two deep-

groove ball bearings equipped with labyrinth-type grease seals for complete isolation of the bearings. A simple stake lock, applied without tools, is provided in the shank to keep the carrier from wobbling and turning in the stake. An ice-shedding finish, applying the principle used on airplane wings, is available on special order.

The equipment is manufactured by The Sisk Company, Wichita Falls, Texas.

400-Amp. Lincoln Diesel Arc-Welder Equipped With Gasoline-Engine Starting

THE application of gasoline engine starting on Diesel-driven arc-welders, announced previously on a 300-amp. unit by The Lincoln Electric Company, Cleveland, Ohio, has



been further extended and is now available on a 400-amp. model (see illustration).

This advance makes available easy starting in any weather and the inherent economies of Diesel drive in the many applications for engine-driven welders of capacities to 400 amp., the manufacturer states.

According to field reports, the Diesel welder reduces fuel costs 33 to 86 percent, the makers assert; total savings being as high as 40 cents per hour. Fuel oil consumption is 1.5 gal. per hr., at full-load operation, compared with 2.75 gal. of gasoline with conventional engine-driven welders, it is stated.

The gasoline-starting engine is a small auxiliary mounted above the Diesel. It is started by means of a hand crank. A belt drive, engaged by means of a clutch, connects the starting engine to the Diesel. Starting in extremely cold weather is facilitated by having the cooling system of the small starting engine connected into the cooling system of the Diesel. This permits warming-up the Diesel by running the starting engine a short time and allowing the heated water to circulate through the Diesel engine.

Of 400-amp. capacity, the "Shield Arc SAE" arc-welding generator used on the new Diesel welder is equipped with "dual continuous control" and all other advanced Lincoln features.

Dual continuous control, by permitting independent adjustment of both voltage and current, provides a welding arc of exactly the right type and intensity for all applications of arc-welding, the manufacturer asserts. Ability to make adjustments in very fine increments, enables the user to obtain literally thousands of current settings. This feature assures fast and economical production of high quality welds under all conditions.

Other features available on the new 400-amp. Lincoln Diesel welder include: extra wide welding range; independent excitation; laminated magnetic circuit; high capacity; high efficiency; cool operation; all-purpose meter, and arc-welded steel drip-proof construction.

A substantial channel frame provides mounting for the entire unit. The frame of the arc-welding generator is attached directly to the Diesel engine bell housing. A special type of flexible coupling connects the generator shaft to the engine flywheel.

GET *In*, AND *Out*,
Where Other Trucks Can't!

There is a noticeable trend toward *greater portability* for all types of oil production equipment. Major companies, particularly, are specializing in exploration and well-servicing equipment which can be moved quickly and inexpensively from one site or well to another, to reduce capital investment, and to speed up operations in the field.

This explains, in part, the tremendous growth in popularity of Marmon-Herrington *All-Wheel-Drive* Fords during recent years among oil field operators. For these are *the only light and medium weight All-Wheel-Drive vehicles on the market.* They are in a class all to themselves in size, price and ability to perform over all sorts of terrain. They give new meaning to the word *portability* as used in the oil fields.

Send for literature describing Marmon-Herrington *All-Wheel-Drive* Fords and Heavy Duty trucks. It will open your eyes to new possibilities of performance and profits. Cable address, MARTON, Indianapolis, Indiana, U. S. A.

MARMON-HERRINGTON COMPANY, INC.
INDIANAPOLIS, INDIANA, U.S.A.

Accelerator Attachment for Feedwater Controller

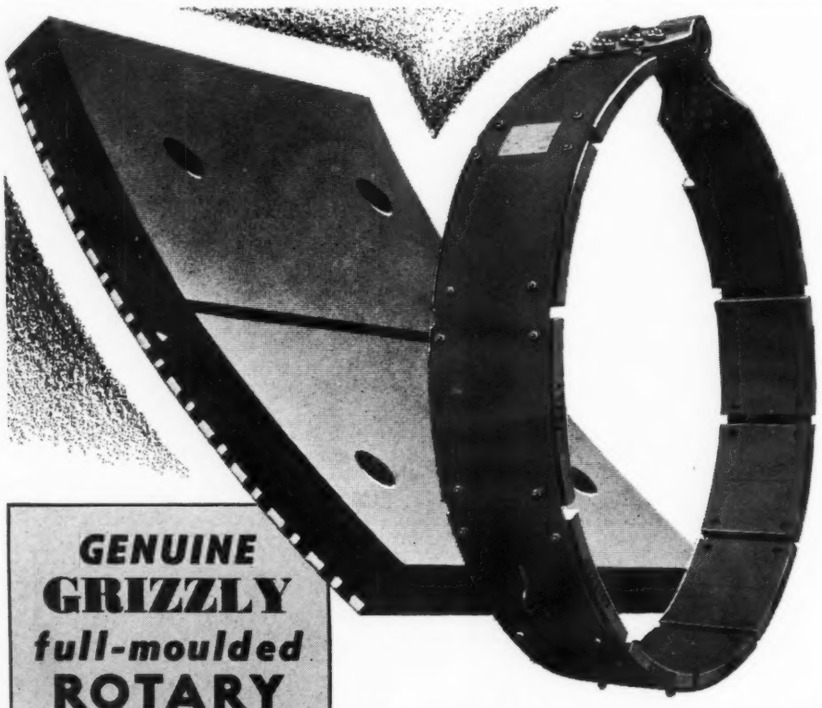
A NEW principle is embodied in a feedwater level controller developed by J. A. Campbell Company, by a simple accelerator attachment. A small stream of water is fed into the control tube at its hot end, increasing valve motion through changing the temperature of the entire tube by positive volume control. In addition to maintaining precise control of boiler feedwater, this controller, with its new accelerator attachment, permits blowing the control tube without throwing the apparatus out of adjustment, the manufacturer states. Thus a simple method is provided for cleaning the control tube of scale or other accumulations, regardless of the temperature of the feedwater. Cooling is accomplished through the extraction of heat from the tube. The cooling water, taken from the feed valve on the upstream side, has full differential pressure to force it into the tube. This differential varies with the opening of the feed valve. A small filter is incorporated in the line between the tap-in on the feed valve and accelerator valve. A back wash valve is provided, through which the filter can be washed and freed of scale or other intruding elements. Only a few seconds are required to wash the line. By the intrusion of the accelerator control, this boiler feedwater controller can be flushed in a few seconds, without disturbing the water level in the boiler. The lower end of the thermostatic tube on the controller is finned, which greatly increases sensitivity. Movement of the operating mechanism occurs when the water level rises or falls in the tube. A novel feature is the audible signal system. The controller can be equipped with either a whistle or an electric alarm so that if the boiler pump should fail, or pump packing should become lodged under the valve, a whistle or electric bell sounds a warning.

Further details regarding the new accelerator attachment and the controller can be obtained from the manufacturer, J. A. Campbell Company, 645 Wardlow Road, Long Beach, California.

Swab Cup Container

THE Guiberson Corporation, Dallas, Texas, has announced a new method of packing swab cup assemblies in the tubing sizes. Since July 1 the cup assemblies have been packed in sealed, air-tight tubular containers. This modern packing assures the producer of fresh stock at all times, as the air-tight feature will delay deterioration of the rubbers caused by atmospheric changes, the manufacturer asserts.

The container clearly shows size and type cup in the package and complete engineering data covering both the swab and cup assembly, it is stated.



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The GRIZZLY ROTARY BLOCK BAND EXCHANGE saves operators time, labor and money and insures better braking performance over a longer period of time. Genuine Grizzly full-moulded blocks, *factory installed* on steel bands for your particular drawworks, are shipped to your rig in exchange for old bands. Installation of bands is simple, fast and easy, and you actually save by using this better equipment. Ask your nearest supply dealer, or write direct, for details and price list.

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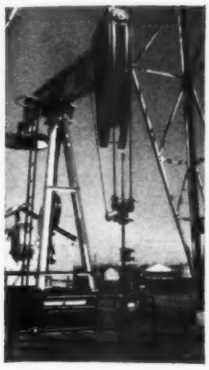
GRIZZLY FULL-MOULDED
ROTARY BRAKE BLOCKS

Apeco Sucker Rod Rotator



THE Apeco Sucker Rod Rotator has introduced a new method designed to allow the rod string of a pumping well to "free wheel," thereby removing strain and minimizing wear and deterioration on the subsurface pumping equipment.

This new product offers a definite solution to numerous pumping well problems inasmuch as it rocks and rotates as it pumps, the manufacturer states.

The rotating and rocker elements combine to eliminate strain on polished rod, stuffing box, and sucker rods by allowing free movement in all directions. This freedom of movement compensates for stress or strain caused by the polished rod not traveling in a perfectly straight position. This is particularly important in the case of crooked holes where extreme strain has resulted in whipping of the complete rod string. The rotating feature has minimized fatigue in rods; has practically eliminated backing-off and parting of the rod string, according to the manufacturer.

It has delayed the formation of paraffin to the extent of requiring the running of a paraffin scraper once a year instead of every 90 days, or oftener, depending on the paraffin condition, it is asserted. The rotating element is actuated from the walking beam, and operates very simply. It is adaptable to all pumping wells.

It is designed to alleviate fatigue to the point of arresting it when already set up by bending or vibration, this being accomplished by allowing the rods to drop more freely. The design also offers a distribution of harmonic vibration, which lessens harmonic fatigue and, by constant rotation of the rods, keeps vibrations uniformly distributed rather than being concentrated, it is stated.

For full details write Advanced Petroleum Equipment Corporation, M. & M. Building, Houston, Texas.

Westco Automatic Boiler Feed Systems

WESTCO Automatic Boiler Feed Systems have recently been introduced by Micro-Westco, Inc., Bettendorf, Iowa. The company lists the following features of its equipment:

Condensate is automatically returned to the boiler, from high-pressure as well as from low-pressure equipment.

Make-up water is automatically added to the condensate as needed to compensate for loss of live steam. There is no appreciable pressure drop due to feeding cold water directly to the boiler.

A constant water level is maintained in the boiler at all times regardless of the steam pressure carried. This eliminates the need for manual operation, maintains a uniform steam space, and guards against damage that might result from low water conditions.

Back pressure on return lines is entirely eliminated.

The system uses no steam, conserving it for plant use.

The Westco turbine-type pump is an integral part of the system. The pump is manufactured by the same company.

The Westco Automatic Boiler Feed System can be used with vertical or horizontal boilers and is applicable in any service using steam for either processing or heating. The systems are available in various sizes to 750 hp. and 200-lb. pressure.

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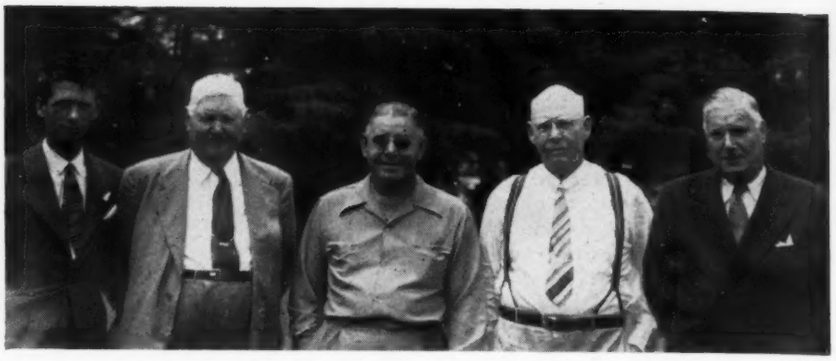
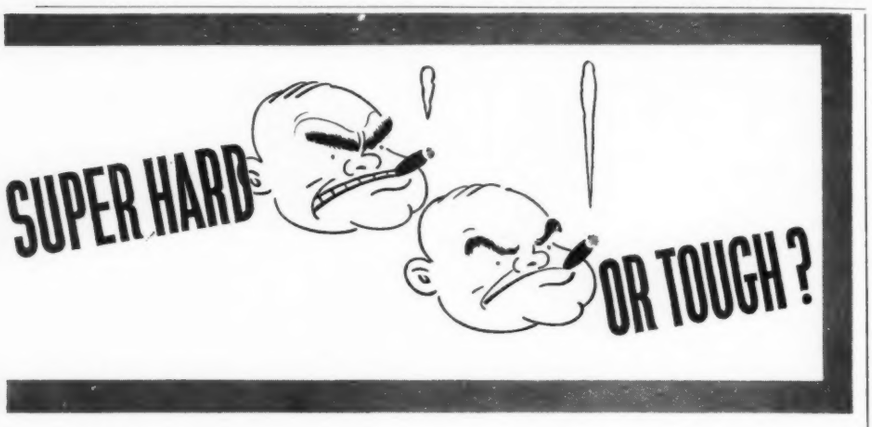
Axelson's Annual Picnic

The eleventh annual Axelson Manufacturing Company employees picnic was held July 27, at the American Legion Stadium at Montebello, California. More than 1500 Axelson employees and their families were in attendance. Games for young and old occupied the attention of those attending from 8:30 a.m. until 5:30 p.m. The tantalizing strains of music of a good dance orchestra held most of the crowd until 11:00 p.m. According to the committee in charge of arrangements, this year's picnic was the largest and best attended to date.



Three generations of one family well-known to the oil industry for nearly a century are pictured here. Left to right: Jack Axelson, C. F. Axelson, retired; J. C. Axelson, president of Axelson Manufacturing Company; G. A. Axelson, chairman of the board of directors; D. F. Axelson, vice-president of Axelson Manufacturing Company



THIS PUMP BARREL IS *BOTH!**

FLUPACO'S "IMPROVED INSERT" Pump Barrel is not *only one solid piece* end to end, but is made under a new process that combines both *extreme hardness* and *toughness* in the one piece of metal.

That's a miracle of modern metallurgy, for it wasn't long ago that a metal could be hard (and brittle) . . . or tough (and not so hard) . . . but not *both* at the same time.

But look at these physicals for the "IMPROVED INSERT" Pump Barrel: *Tensile Strength—145,000 p.s.i.* . . . a sizeable tensile in *anybody's* language. *Hardness—64 to 70 Rockwell "C" Scale* . . . and mister, that's *hard*—hard enough to stand plenty of severe service under the most abrasive conditions.

Another thing—don't forget that the "Improved Insert" barrel has an inside wearing surface deep enough to permit numerous re-hone jobs . . . an important point that means less maintenance expense.

Combine those features with the *rigid* one piece barrel that has no joints to get out of alignment . . . or leak . . . or cause uneven wear . . . and you have pump performance that will open your eyes.

Altogether, there are more than a dozen new performance features about this "IMPROVED INSERT" Pump that you should know about. Before you buy *any* pump, let us show you what the *jointless* barrel of the "IMPROVED INSERT" Pump means to your pumping costs. Your nearest Fluid Packed dealer has the information . . . or write direct for 8 page illustrated bulletin. No obligation, of course.

FLUID PACKED PUMP CO., POST OFFICE BOX 64, LOS NIETOS, CALIFORNIA

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* FLUPACO "IMPROVED INSERT" PUMP

Airco Announces Retirement of William W. Barnes

The Air Reduction Sales Company has announced the retirement of William W. Barnes, manager at Philadelphia. Barnes, who has won the admiration and respect of the entire oxy-acetylene industry as a result of his keen insight and pleasant personality, has been active in the industry for 30 years.

WILLIAM W. BARNES

William W. Barnes first became associated with the oxy-acetylene industry in 1910 when he joined the Davis-Bournonville Company as Philadelphia sales manager. He held that position until 1922, when Davis-Bournonville merged with Air Reduction. As a result of the merger, Barnes became Airco's manager at Philadelphia—a position he has held until his retirement.

Correction

In the June issue of *The Petroleum Engineer*, page 122, column 3, line 12, "0.82" should read "0.22", and the reference to A.P.I. gravity, in parenthesis, should be eliminated.